WONDER BOOK
OF THE
WORLD'S PROGRESS

VOL IX

ART • SCIENCE

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INTRODUCTION

IT was not by mere accident that the discovery of America took place toward the close of the fifteenth century The voyage of Columbus might rather be considered as an inevitable part of the impulse to reach out into new fields of thought which characterized the epoch in which Columbus lived. The racial minglings of the Middle Ages resulted in an ultimate blend that effectively rejuvenated the populations and insured the production of quotas of men of genius, upon whose activities all progress of civilization depends

Thus the period to be known to the later historian as the Renaissance was ushered in It first manifested itself very tangibly in Italy, but presently it ignored national bounds and encompassed all Europe It involved also every department of physical, intellectual, and emotional activity Without exaggeration it may be spoken of as an heroic age of art, science, and letters—meaning all the graphic arts, the entire field of both theoretical and experimental science, and every department of literature

The text of this volume will give glimpses of certain intellectual aspects of this consummate movement In particular we shall tell the story of the investigations in the field of science which resulted in the most stupendous intellectual revolution to which the mind of man has ever been subjected

At the beginning of the era, it was universally believed that the earth is a stationary globe at the center of the universe The natural and universally accepted

inference was that man, the observed "lord of creation," is the central figure in a universe created primarily as his abiding place.

At the end of the era, it had been revealed that the earth, instead of standing at the center of the universe, is but a minor planet circling about a sun which, tho almost infinitely larger than the earth, is itself but one among myriads of suns making up a universe of unimaginable proportions.

Even in our day, the world has only partially adjusted itself to this revolutionary conception of man's position in the universe. No intellectual revolution to which mankind can be subjected in the future can ever even approximate in character or significance this transformation, which became inevitable when the investigations of a small company of searchers in the field of science revealed new and true interpretations of old and familiar phenomena of earth and the heavens.

The story of these investigations and of the tangibilities they revealed is told in the pages of the present volume. And for background, to suggest the milieu, reproductions are given of the great works of art — cathedrals, sculptures, paintings, etchings—which were created as natural results of the ethnic urge of the new era.

Of less importance, but still not without cogency, is the incidental presentation of some salient aspects of the military and political activities of the period. But the mere national upheavals, in the last analysis, are trivial —even tho they make up the main records of history as ordinarily written. Even the artistic creations—tho they include the work of such giants as Leonardo, Michelangelo, Titian, Valesquez, Dürer, Rubens, Rembrandt in the field of graphic arts, and Dante, Cervantes, Rab-

elais, Spenser, Shakespeare, Milton in the field of letters—must be accounted, in the larger and more comparative view, of minor significance

These artistic creations were, after all, only modifications and developments of the artistic creations of earlier epochs. Architecture revealed modified ideals, but could hardly be said to overshadow the architecture of Egypt and Greece. Sculpture at best can be appraised as approximating the standards of near-perfection of the Greeks in the age of Phidias and the Parthenon.

Painting did indeed attain new heights, under the inspired touch of Leonardo, Michelangelo, and their confrères, but even the murals of the Vatican represent perfection of an art that was as old as the age of the cave-dwellers—an evolution, not a revolution

Similarly the inspired craftsmanship of Dante and Milton illustrated only the practise of a prehistoric craft that had been brought close to perfection by the bards of the Homeric age at the very dawn of history And the dramatists of the new era — Jonson, Shakespeare, Molière—modified the methods but scarcely improved upon the technical craftsmanship of their remote forebears—Æschylus, Sophocles, Euripides, and a host of others—of the Golden Age of Greece. All along the line, then, there was rejuvenation, evolution, but no actual transformation of ideals or of method

But in the field of science there was veritable new creation. The telescopes of Galileo and his successors penetrated the heavens with new vision. Kepler and Newton and their fellows gave new interpretations of natural phenomena and formulated rules called "natural laws" hitherto unknown or at most vaguely suspected; and, as has been said, the net result was, not merely new knowledge of natural phenomena, but a complete

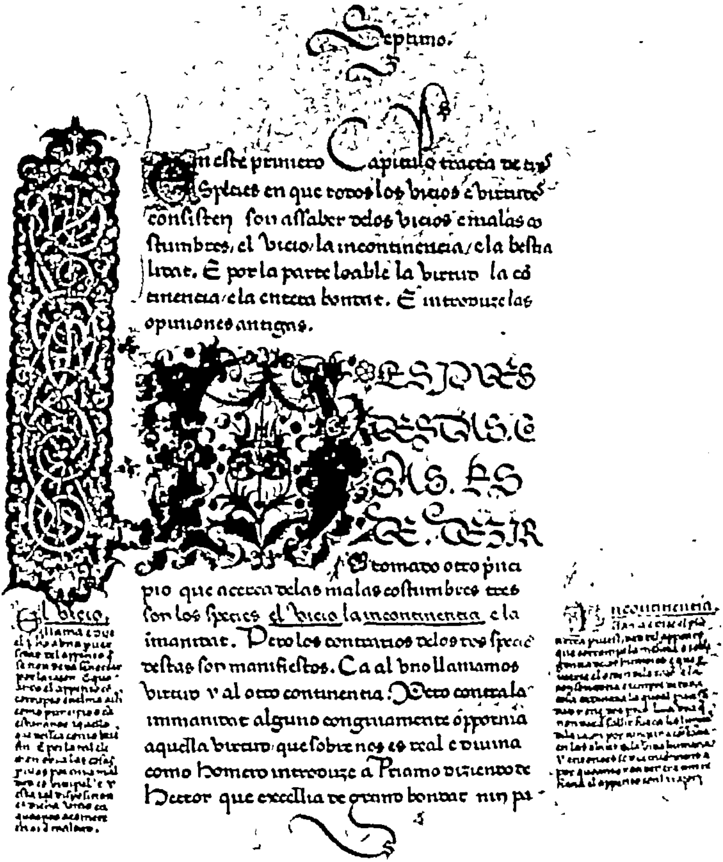
revolution in man's conception of his own relation to the universe

It was not alone in the field of cosmology, however, that men were active during this period of intellectual rejuvenation It became the fashion to challenge all manner of natural phenomena. In an earlier volume we have seen something of the developments in the field of the mechanical sciences. In the present volume we shall catch glimpses of investigations of the new types carried out in many other directions In particular, we shall single out for somewhat more extended examination the researches that terminated in Harvey's epochal discovery of the circulation of the blood

These and numerous other lines of research, including the monumental work of Linnæus in the field of natural history, were manifestations of the same newly aroused spirit of challenge of natural phenomena. They were parts of the new interpretation of natural phenomena which prepared the way for the amazing developments of the nineteenth century.

BOOK I

THE ART PRESERVATIVE OF ARTS



Septimo.

En este primero Capitulo tracta de tres especies en que todos los vicios e virtudes consisten son assaber delos vicios e malas costumbres, el vicio, la incontinencia, e la bestialidat. E por la parte loable la virtud la continencia e la entera bondat. E introduze las opiniones antiguas.

Despues [illegible] Aristotiles [illegible] ovo tomado otro principio que acerca delas malas costumbres tres son los species el vicio la incontinencia e la immanidat. Pero los contrarios delos dos species destas son manifiestos. Ca al uno llamamos virtud y al otro continencia. Pero contra la immanidat alguno conguiamente opponia aquella virtud que sobre nos es real e divina como Homero introduze a Priamo diziendo de Hector que excellia de grand bondat nin pa-

El vicio [illegible]

Incontinencia [illegible]

ARISTOTLE'S TREATISE ON ETHICS (A D 1458-1461)

I

THE ART PRESERVATIVE OF ARTS

WE have seen that the Greek language disputed supremacy with the Latin at Rome itself, even at the time when the Latin race, as such, was dominant in the world. When the seat of the empire shifted back to the East, Constantinople succeeding Rome as the capital, the Greek language became not merely dominant as a literary medium, but also as the court language and the language of every-day life. Naturally, then, the works of this period were practically all written in Greek.

It was not the classical Greek of Homer and Æschylus and Herodotus, to be sure. It had undergone changes, generation after generation, such as no language escapes. Yet it was only in the niceties of grammatical form of termination and of syntax that it had been modified. In its main structure the Greek of Byzantium was the same language that had been employed in Athens when that city was the literary center of the world. Moreover, this same slightly modified tongue was to be perpetuated throughout succeeding generations to our own time. The language used in Greece at the present day is the direct lineal descendant of the language of Homer. Latin became veritably a dead language in the Middle Ages. Its descendants, Italian, Spanish, Portuguese, French, and the less important Romance dialects are so greatly modified from the parent form as fully to deserve the name of independent languages.

A knowledge of Italian helps one but little in the interpretation of classical Latin, but with modern Greek the case is different It is true that it is usually spoken of as a distinct language, and that in many ways its forms are changed, yet the modern Greek finds it a comparatively easy matter to turn to his classical authors. The main structure of his language is obviously one with that of the old Athenians, and we have here illustrated an example of one of the longest-lived languages of which we have any knowledge No language can persist without change But the Greeks possessed the elements of conservatism in a wonderful measure

The Byzantine writings, then, are couched in modified Greek There are no great authors represented in the period, tho there is a long list of respectable ones.

For purposes of illustration of the development of the art of writing, we must turn to copies of the classical authors, rather than to originals of this period, since most of the latter have disappeared. It is an unusual fate for any manuscript whatever to be preserved more than a few centuries after it is written. The authors that have come down to us are those that presented sufficient interest for the copyists of the Middle Ages to be reduplicated again and again. Manuscripts of Homer are more abundant than perhaps any other writings, for the obvious reason that Homer enjoyed an enormous popularity from the earliest classical times throughout the Roman period and Middle Ages. Even those of Homer, however, did not escape the fate that befell so many other manuscripts, a fate illustrated in one of our facsimiles This is what is known as a palimpsest; that is, a manuscript that has been erased more or less effectually, in order that another writing might be substituted In the present case the later writing is in Syriac.

Very generally in the Middle Ages the ancient author was replaced by theological writings, usually the lives of saints. Great numbers of classical manuscripts were thus destroyed, but, fortunately, in many cases the erasure was but partial, so that it is still possible to decipher the original writing. These theological writings were often esteemed so highly that it was quite a common practise for the owner of a book, when inscribing his name upon it, to record a curse upon the head of any one who should steal the volume, or even alter any part of it, when making a fresh copy

The making of palimpsests was possible even with papyri, but it was never extensively practised So long as this material was chiefly used, it was quite a common thing in Egypt to make use of the back of the papyrus roll for purposes of preserving later documents Such an instance has been seen in connection with a farming account on the back of which was written Aristotle's *Constitution of Athens*. But the material is too fragile to lend itself readily to erasure. In the Roman period, however, papyrus had been largely superseded, outside of Egypt, by parchment as the material for books, and this much tougher substance could be treated in a way not possible with the more fragile books of the Egyptians

The Byzantine Empire, overthrown by the Mohammedans in the fifteenth century, left no direct successor, and the historians of Europe have rarely done full justice to the culture that had its seat in Constantinople during those centuries that we think of as constituting the Dark Ages

In point of fact, literature flourished abundantly in the Eastern Empire throughout this period, and if few great works were produced, at least there was a constant company of readers who could appreciate the great masters

of old, and who filled their libraries with them, and no doubt read them at least as eagerly as the classics are read in our own day

As a witness to the abundance of literature in this period, it may be noted that there are at present in existence in the various libraries and collections of Europe at least a thousand dated manuscripts written in Greek prior to the fifteenth century. The major part of these are not earlier than the ninth century, as very few, indeed, of the older manuscripts bear any date.

There is then a wealth of material illustrating the developments of the Greek script in the Middle Ages

These facsimiles show the very great change in the form of the Greek characters through the development of the cursive script, which became perfected about the tenth century and afterwards degenerated considerably When printing was invented, the later forms of the Greek minuscule—that is to say, those that were then current—were quite naturally adopted for the printed language; but subsequently reversion was made to the forms of the letters employed in the tenth and eleventh centuries, and these are the forms still employed.

It would appear that a somewhat sudden transformation was effected in the characters employed in writing Greek in the eighth and ninth centuries. Prior to that time the uniform script was in what are termed uncial characters; that is to say, all the letters were practically of one size, corresponding rather closely to our capitals. But in the ninth century there suddenly appears this modified script, which, because of the size of the letters, is called minuscule, and which seems almost immediately to take full possession of the field

II

DEVELOPMENT OF THE LATIN SCRIPT

THE capital and uncial letters used throughout the Roman period and in the early Middle Ages had obvious disadvantages for the purpose of book-making. In the first place, they could not be made very rapidly In the second place, they are large, and therefore occupy much space. The first objection might often be overlooked where the book-maker was a monk with no practical affairs to attend to, for he could devote the best part of a lifetime to making a few books. But the question of material was not so easily gotten over

In the early Middle Ages, when books were comparatively few, a paucity of material was, perhaps, not urgently felt: some books were of enormous size, a page even twenty inches high, and a volume composed of a thousand pages. But as time went on there came a relative revival of learning, and the book-making spirit grew apace. The facilities for securing parchment, which had now become the chief book-making material, did not increase with this need. Parchment became very expensive, as well as difficult to procure, and, as we have seen, the expedient was resorted to of erasing classical manuscripts that the new writings might take their place.

The lover of literature—and no doubt the bookmaker generally was such—must have had many misgivings in thus destroying valuable manuscripts of antiquity, and quite naturally he cast about for a means to overcome the dearth of parchment without resorting to this prac-

tise One very obvious way of effecting this in part would be a reduction in the size of the letters employed in book-making

In many of the older books, the letters are not merely capitals or uncials, but are made very large at that, sometimes even an inch in height, so that comparatively few words could find place even on a large page. Such extravagant waste of material was soon corrected, and the average size of uncials of the fifth, sixth and seventh centuries is not very great Still, the nature of an uncial does not permit of its being made very small, or rather, perhaps it should be said that if the character is made very small it ceases to be an uncial

This is precisely what happened in the course of the Middle Ages. First there was a tendency slightly to modify an ordinary uncial character It has been pointed out that a tendency to cursiveness is seen toward the end of the lines in many uncial manuscripts, the scribe obviously having become impatient with the slowness of production To meet this difficulty — a difficulty that every writer of books must more or less have felt—a natural expedient would be the adoption of a cursive script. But there is a radical objection to this. A cursive script, however carefully formed at first, tends to be more and more careless, until finally it becomes illegible

In Southern Italy in the thirteenth century, Frederick II issued an edict suppressing the illegible script then current there in business documents This script must have been bad indeed, for business documents are relatively ephemeral, and a very illegible script could be tolerated in them which would be quite inexcusable in a book Books were made for the market, to be sold to some one who desired to read them, and too bad a manuscript would obviously be unsalable

THE VENERABLE BEDE (MS OF 12TH CENTURY)

[...]incga · 7 æt cingestune gehalgod, 7 he geaf his sweostor [...]

an. dccccxxvi. an. dccccxxvii. an. dccccxxviii. an. dccccxxviii.

an. dccccxxix. an. dccccxxx. an. dccccxxxi. an. dccccxxxii.

an. dccccxxxiii.

dccccxxxiiii. Her for æþelstan cing on scotland ægþer ge mid land here ge mid scyphere. 7 his micel oferhergode.

an. dccccxxxv. an. dccccxxxvi.

dccccxxxvii. Her æþelstan cing, eorla drihten, beorna beahgifa, 7 his broðor eac eadmund æþeling ealdorlangne tir geslogon æt secce sweorda ecgum embe brunanburh. bordweall clufon heowon heaþolinda hamora lafum. afaran eadweardes. swa him geæþele wæs fram cneomægum þæt hi æt campe oft wiþ laþra gehwæne land ealgodon, hord 7 hamas. hettend crungon. scotta leode. 7 scypflotan fæge feollan. feld dennade secgas swate. siððan sunne upp on morgentid. mære tungol glad ofer grundas godes condel beorht eces drihtnes oð sio æþele gesceaft sah to setle. þær læg secg mænig garum ageted guman norðerne ofer scyld scoten swilce scyttisc eac werig wiges sæd. wesseaxe forð andlangne dæg eoredcystum on last legdon laþum ðeodum. heowon hereflymon hindan þearle mecum mylenscearpum. myrce ne wyrndon heardes handplegan hæleþa nanum þara ðe mid anlafe ofer ear gebland on liðes bosme land gesohton. fæge to gefeohte. fife lagon on þam campstede cingas geonge. sweordum aswefede. swilce seofone eac eorlas anlafes. unrim heriges. flotan 7 scotta. þær geflymed wearð norðmanna bregu nede gebeded to lides stefne lytle werode. cread cnear

ANGLO-SAXON CHRONICLE (MS OF 1045 A.D.

Two contradictory desirabilities, therefore, confronted the bookmaker after the revival of learning had made a ready market for his product On one hand he would produce many books; on the other he would have his product legible. Neither the uncial script previously used in book-making nor the cursive script of every-day life met these conditions, therefore a compromise script was evolved which was intermediate in character; more cursive, and therefore more readily written than a book hand, yet much more legible than the ordinary business hand.

This new form of script was written in small characters, which, therefore, came to be called minuscules Once thoroughly developed, this minuscule hand took the field for all ordinary books.

Volumes of the nature of editions de luxe, chiefly composed of Bible manuscripts or of standard works of the saints, were still issued in the old-time uncial; but the generality of books after about the ninth century used the other character. This minuscule character reached relative perfection in the tenth and eleventh centuries, afterwards degenerating with use, as is the nature of scripts.

It is the character of the tenth and eleventh centuries that has served as the model for the modern type of our printed books of today.

The books of this period are made uniformly of parchment, and they have the form of modern books, bound precisely after the manner of printed books of today.

There are certain other modern features that distinguish these books from the earlier ones. Notable among these is the fact that punctuation marks are used much more freely, and that words are often marked off from one another by spaces. The use of capitals at

ANGLO-SAXON POEM OF CÆDMON
(11TH-CENTURY MS)

III

THE DEVELOPMENT OF THE BOOK HAND

DURING the last five centuries preceding the invention of printing, the minuscule character was altogether predominant, and the exact formation of the letters underwent only such slight modifications as the tastes of the individual scribe suggested, the general trend being toward a greater elaborateness and an increase of ornamentation, which does not add to the legibility, however it may affect the beauty, of the page

We have already noted that the modern type-maker has reverted to the more simple eleventh-century character Meantime, it will not be denied that the fourteenth- and fifteenth-century scribe had developed a marvelous degree of skill in printing with the pen; in many cases so uniform in size and outline are the letters that even a careful observer might mistake this script for printing

During these later generations of the Middle Ages there was doubtless an increasing book market almost everywhere in Europe. The generality of people were still, no doubt, unable to read, but there was an ever-increasing company entering the ranks of scholarship, and the number of books preserved bears testimony to the respectable size of the reading public

Even at the close of this period the classical author held the field almost undisputed. For nearly a thousand years there was almost no permanent literature of a high rank produced in Europe. It is true that toward the close of this period we are entering the modern epoch Dante

and Petrarch have appeared in Italy; Anglo-Saxon literature is nascent in the writings of Roger Bacon and those of the Chroniclers, and in the poems of Beowulf and Piers Plowman; and, finally, a sure note has been struck by Chaucer and the way prepared for that galaxy of moderns with Bacon, Shakespeare, and Milton at their head, who are presently to contest supremacy with the masters of old.

But tho the time is ripe for this new flowering of literature, we are only at the verge of the epoch that is to usher it in, and for the moment classicism is still dominant. Could we look into a library of the time, we should find chiefly the writings of the old Greeks and Latins. Seneca and Valerius Maximus, Terence, Cicero, Sallust and Quintilian are fairly representative of the selections which we should find in the average library of the fifteenth-century scholar. There would be Greek books also, tho probably in smaller number.

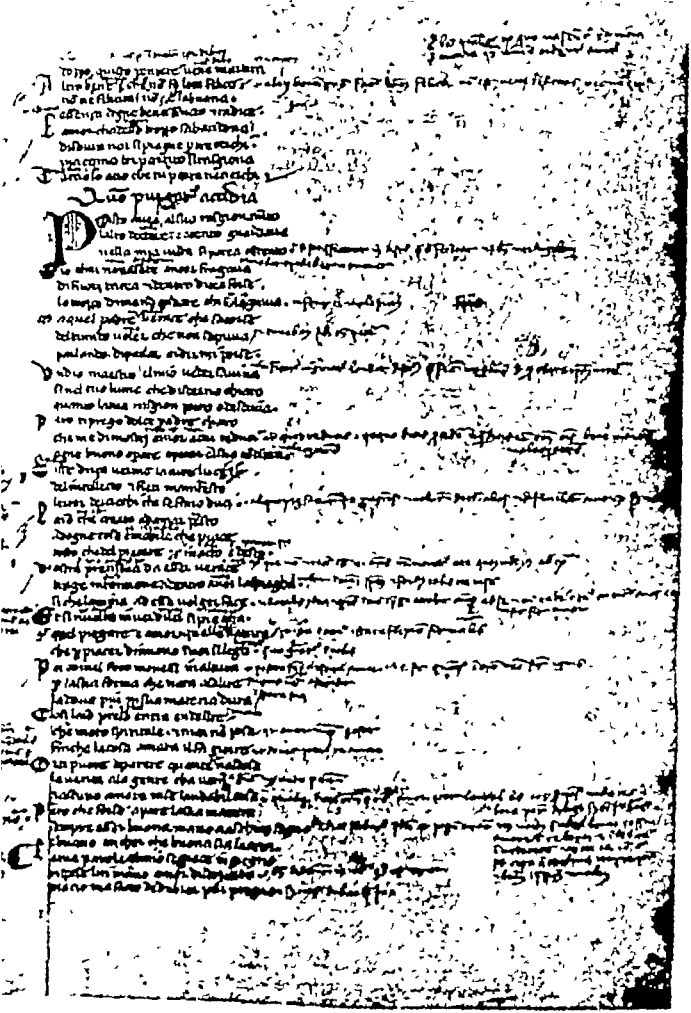
One of our facsimiles shows a Cicero written in 1444. Little did the scribe who slowly and painstakingly indited it suspect that he was practising an art that had already received its death blow. Yet so it was; for two years earlier, in 1442, Johann Fust had established at Metz his printing press and ushered in the new era.

As we stand now at the threshold of this new era, after traversing the mazes of a long series of manuscripts, many reflections suggest themselves. One of the most curious of these, and one that must have come to the mind of many a reader, is the question, What is the normal life of a manuscript? Books, no less than animate objects, are born to die. Even the least destructible of them, as the clay tablet of the Assyrian and the brass plates of many nations, are after all at the mercy in varying degrees of flood and fire, and moth and rust.

It would be extremely difficult to answer the question as to the normal life of a manuscript with any pretense of scientific exactness. But perhaps it would not be an unfair estimate to ascribe to manuscripts an average life about equal to that of a human being Such an estimate must be based on the supposition that the vast majority of manuscripts are very ephemeral, indeed; but this assumption is abundantly justified. Who can doubt that the greater part of the writing produced last year has already been reduced to its elements in smoke, or dust, or pulp, or powder? Beyond question, in this age of great productiveness and of cheap paper, most manuscripts die in infancy, or at best attain a tender adolescence. But, on the other hand, we have had ample proof of the fact that a certain select number of manuscripts, the Methuselahs of their kind, attain an age which even the most perfervid imagination of patriarchal times never dared claim for any human being.

We have seen documents from Babylonia, whose clear-faced script brings us a message over the chasm of 7,500 years, and inscriptions from Egypt only a little less venerable. There are whole libraries of Assyrian books that are more than 2,500 years old.

But, on the other hand, consider the vast quantities of books of all intervening ages that have met a less kindly fate There is no reason to suppose that the stores of Nineveh that have come down to us are more than a handful in comparison with the Assyrian books that are lost; and of all the abundant output of the great masters of Greece and Rome, from Homer and Hesiod to Plutarch, Livy and Tacitus—nay, even to their degenerated successors of the Byzantine period and the rejuvenators of literature of the Renaissance—of all this vast store of manuscripts of Greece and Italy, the product of 2,000



DANTE A MANUSCRIPT OF 1379 A D

ANOTHER PAGE OF CÆDMON'S POEM
(11TH CENTURY)

years of human effort, not a single line has come down to us in the original draft of the classical author himself.

The law of the survival of the fittest has applied here as rigorously in preserving the best productions as with animate creatures, but its application in this case, as in the other, has been in favor of the class and not of the individual.

The works of Homer, of Herodotus, of Xenophon, Thucydides, Virgil and the rest have been preserved because their never-ceasing popularity led to their being duplicated generation after generation, and in many widely separated regions; with like persistence, that jealous destroyer, Time, removed not only the original manuscripts, but the vast majority of the copies also. Here and there a stray waif was spared to preserve the thought of antiquity for the delight of after ages.

But what an army of copyists—fallible, mistake multiplying copyists—stands between us and the original manuscript which recorded the thought of the master mind itself!

In this day of the printing press every book of any given edition is expected to be like each one of its fellows, tho these are counted in hundreds of thousands. But in the old days, when the pen was dominant, it may well be doubted whether any two copies of any book were ever alike in their every word. Any one familiar with manuscripts knows that these differ, and every student of the classics is aware that with scholarly editions of these works as now printed, the foot-notes devoted to the discussion of "variorum" readings quite generally crowd the original text itself into a few thin lines at the top of the page.

This merely illustrates the fact that human copyists are fallible, and that, essential tho they be to the trans-

mission of the author's thought, yet, thanks to them, that thought is transmitted to posterity, not in a fixed integrity of form, but as a plastic organism, to be more or less moulded into strange and unintended shapes in after time, much as an animate being is slowly changed by its environment.

Were the work of successive generations of copyists to go on long enough, we should finally have a crop of literary offspring for every great masterpiece, which would differ as much from the original masterpiece itself as the different races of man, for example, differ from one another, tho sprung from one original parent stock. If one doubt this let him consider the "variorum" editions just referred to.

Thus an edition of Livy lies before me, which, thanks to notes on variant readings and critical interpretations of doubtful passages, is spread over 14,000 large pages, mostly of very fine type, whereas all the words of the text proper would probably not require more than as *many hundred pages at the most.*

The famous Delphin set of Latin classics occupies, thanks to the "variorum" feature, no fewer than 141 bulky volumes, a score of which would probably suffice for the text of the Latin authors.

As another illustration of the changes to which the thought of an author becomes subject, consider the different translations that have been made from time to time during the past 300 years, of the most popular classical authors. How widely the text of such famous translators of the older time as Philemon Holland and Arthur Golding differs from the texts of Arnold, or Rawlinson, or Clinnock!

Or, to choose a yet more vivid illustration, consider that most familiar of all translations, the Authorized

English Version of the Bible. The original manuscripts from which this translation was made were themselves removed by a thousand years or more from the hands that first wrote their prototypes The translators then were obliged to choose between variant readings, adding thus their own interpretations to the sometimes mistaken interpretations and faulty readings of the copyists

Once the translation was made, however, it received the stamp of authority, and it has been accepted by successive generations of readers as the phrasing of the veritable words of the ancient speakers

Yet throughout all this time every scholar has been aware that it had no such status, and of late an increasing army of exegetists has cried out against the inaccuracies and even the actual misrepresentations of the original text, with which the Authorized Version is alleged to abound

We are told, to cite but a single example, that such a magnificent passage as the familiar, "Remember now thy Creator in the days of thy youth" has no counterpart in phrase or meaning in the original text from which it was alleged to be drawn

But are we to suppose from this that the popular mind will now relinquish the long-cherished translation, and take in its stead a new and more literal one? Far from it Even tho we are assured of the inaccuracy of such a passage as that just cited, none the less will that passage continue to trumpet itself in our ears, and to stand for us as the phrasing of a Hebrew prophet of old. What the author really said, it would appear, referred not to man's relations with his Redeemer, but purely to domestic affairs "Consider thy wife," runs the original: "Remember thy Creator," the translation

The divergence is wide enough to illustrate the point

in question, namely, that an author's meaning may be greatly modified as transmitted down the generations.

But translations aside, the works of our own language afford sufficient illustration of our text. Shakespeare lived only 300 years ago, yet a page of the first folio edition of his works seems strangely archaic to the modern eye, and the annotations to which his lucid phrases are subjected rival in bulk those with which the classical writings of antiquity are favored

The case of Shakespeare again furnishes a striking comment on the life of manuscripts. In the view of the paleographer, Shakespeare is a modern, yet of all his voluminous writings, every line of which, no doubt, was first transcribed in his own hand, not a single scrap has come down to us in the original. At best a few signatures to business documents remain, treasured as sacred mementoes in the museums that are fortunate enough to possess them Even the proper spelling of the name of the great bard is subject to dispute and learned controversy. Yet Shakespeare was by no means the obscure person in his own day that he is sometimes represented as being He was the most successful of practical dramatists, and it has even been asserted that he was the first man of letters who was ever able to retire in middle age and live comfortably on a fortune earned solely with his pen

If, then, the manuscripts of this greatest and most popular of writers have all disappeared within a few generations of his own time, it is obvious how largely an element of chance enters into the life of manuscripts in general

The oldest example of Greek writing extant—the Abu Simbel inscription—recorded the names of its authors, and some of the oldest papyri from Egypt preserve to

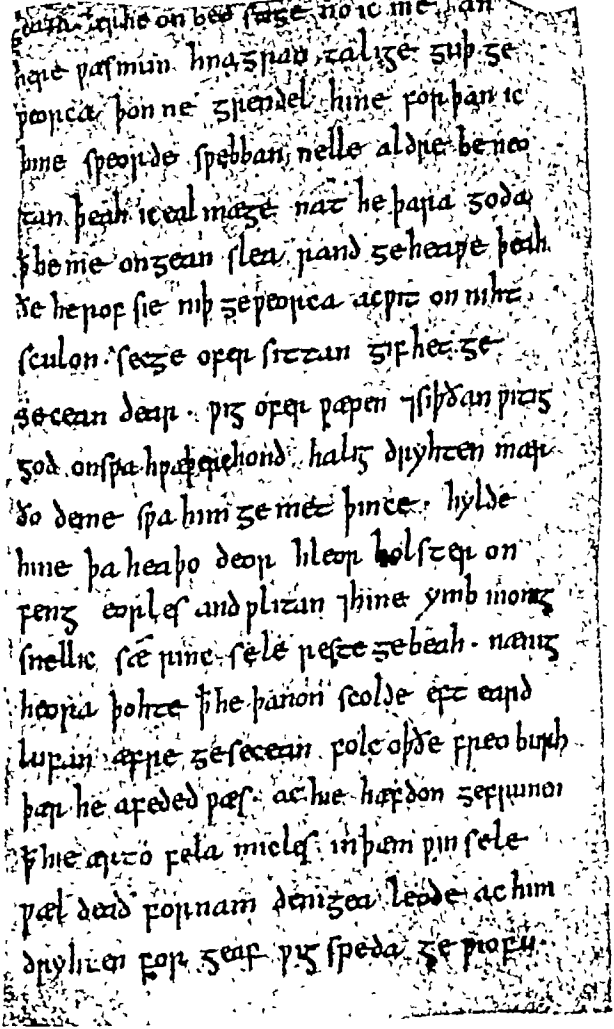
Cand ze faiten yus wip wonge selde frendes wondey me ypnkey
Ant Dobbel drenke yolde ni sie misdisse
Cpanne comence ful curteisly a countenaunce made
And preigte upon patience to pane me to be stille
And seide him self sire Sodeyn so hit be zonge skille
What is Dobbel and Dobbere ze Symmins bnodkep
Cthane i seide seide ye Sodeyn can sene no bettre
sfore so as Sodeyns tellep of yt Dobbel i hit holde
yat thanaldey to teche opnes for Dobbel i holde hit
And he yat Dop as he techep i holde hit for ye beste
Cdm facit + Sodeyn magnus nocabitur
Cwolde yolde clergie quod conscience cnpe what is Dobbel
Thane me exeuse quod clergie di cpst hit m stole
Schal no skidy mopng be meuere for me dint peye
sfor peyes lone ye ploupman yat impugnese me ones
Alle pipne cunnpnges and alle pipne chartres
Fame lone and lande and lolnesse of heyte
And no tpst to take to prene pis for tpelue
Ant Obligo tibi + pyinii and stue pius breuiat i tabularii tu
And pronep be pilpy skille nupht alle pondes Nemo bonus
Ant lel lone and tpipe yat loy is to be founden
Cthanne peyes ye ploupman patiences mincnit
pi fore gpeuel pees i schal pnen yat i sede
And a wolde di fore gas and for sake hit meneie
yat disse Sodeyn sm and pyin eumy
Deyreth yolk him helpe eneene fapy pi mpth
Cthat wore coles on his hed of alle pipnde speche
sfonde wip pi wit and wip pi wordes his lone forte wpnne
And zef him eft and eft enuye at his neste
Comforte him wip pi circle and wip pi pipnde speche
And lauhe on him pus wip lone and he lauhe on pe
And bint he bolde for pis betyng dipne mote i thepue
Cthan when he hadde i wordes pus wiste no man ape
Whey peyes ye ploupman di counsel preuelh he wente
And resen pan after and preh wip him zede
Fame conscience and clergie i conse no mo apple
Cthan patience preuelh spak to peyes thas pus passed
yat lonep lelh quod he bint litel pipnd conseyep
Cwolde and i pil hadde wpnne al fraunce
Wip oute trennyng of heynes or enp blod schedyng
Cpalle wordnesse quod he at holikirch i pnze pacientes mnait

us the names as well as the individual chirography of the obscure persons who produced them. Writings that in themselves were worthless have thus been by mere chance preserved, while others that would be held as priceless mementoes of the great men of the epoch have perished.

After all, however, it is only the antiquarian and the dilettante who need greatly mourn over the destruction of the original manuscripts of our classical authors; for all that has been said about the variations to which the writings of antiquity are subject through the mistakes or wilful misinterpretations of copyists must not be allowed to obscure the fact that in the main the writings of antiquity have come down to us preserving in high degree their original form

It has been suggested that in time the different editions of a man's work would come to differ as widely from one another as, for example, a negro differs from a white man. But it must not be forgotten that even the differences here connoted are differences of detail, and that the points of resemblance between even the most aberrant types of the human race are enormously preponderant over any details of difference

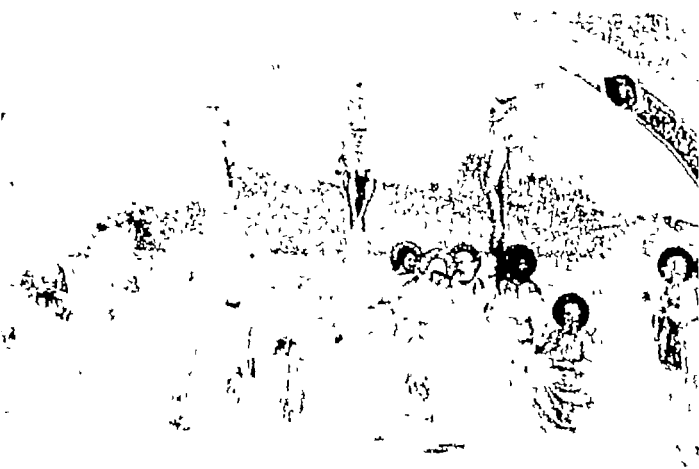
So it would be with the manuscripts. Homer, in a score of different editions, would present variations of here and there a word which could give endless entertainment to the commentator; yet it would still be Homer; a hundred, even a thousand words of all the various editions are identical, where one word differs. And if the divergence may now and then be so significant that the sense of a particular paragraph is utterly changed, yet this is only as the color of eyes or hair, or complexion among men, while the main bodily organism remains the same.



BEOWULF ANGLO-SAXON EPIC OF UNKNOWN AUTHORSHIP (CIRC 1000 AD)

In the main, then, the comforting thought with which one may leave the manuscripts of antiquity is that these manuscripts, however many copies removed from the original, fairly represent the thought of the author in its broad essentials

Bible exegetists tell us that no less than 150,000 discrepant readings are to be found among the thousand Bible manuscripts that have come down to us; but they assert at the same time that all these variations, enormous as they seem when listed numerically, are insignificant in comparison with the body of the text Similarly, considered in the large, the pages of Terence, of Cicero, of Sallust, of Quintilian, as presented in a fifteenth-century garb, stand essentially as their authors meant them to stand. No page is identically as written, but most pages are essentially as written



CRUCIFIXION, BY FRA ANGELICO (1387-1455)

PRAYER-BOOK OF KING HENRY VI

IV

ILLUMINATED MANUSCRIPTS

PALEOGRAPHERS of the early days sometimes discussed at length the question of the origin of the art of illuminating books By some it was asserted that this art was first practised among the Greeks. Others contended that it arose among the Romans, and by yet others it was believed that the art was first practised extensively in Byzantium But a wider study makes it evident that all these conjectures were quite futile It would be nearer the truth, probably, to say that the art of illuminating books is as old as the art of bookmaking itself

We have already seen numerous illustrations of this practise The Egyptian *Book of the Dead* has furnished us with tangible proof that the illustration of books in color was known and practised in Egypt long before Greece and Rome came into existence, and certain Mexican manuscripts prove that so distant and different a race as the Aztecs had developed a system of book illuminating before any white man set foot upon the continent of America

Indeed, inasmuch as the first efforts at writing everywhere are conceded to have been picture writings, and inasmuch as the love of color is known to be characteristic even of the most savage tribes of man, we have every reason to suppose that picture writing in color was practised long before the art of writing had developed to the stage of syllabics and alphabets.

But the making of colored pictures to illustrate ideas is virtually the essence of one of the most highly developed forms of illumination; that, namely, which led to the making of miniatures Moreover, a sense of decoration is of course implied in the use of color in these crude earliest pictures, and the most elaborate form of illumination, aside from the use of miniatures, is by the application of the idea of decoration in conformity with the developed artistic sense

To what extent the Mesopotamians may have practised illumination can only be conjectured Layard found in the ruins of Nineveh traces of color on many of the bas-reliefs that he excavated there More recent excavations have revealed a Procession Street from Babylon to Borsippa, paved with colored mosaics of animals. It is believed that the Assyrians made use of papyrus, or parchment, or some allied substance in bookmaking, tho no specimens of this form of book have been preserved But we have already seen, as transcribed from the walls of Nineveh, the image of a scribe writing on a roll or sheet of this character

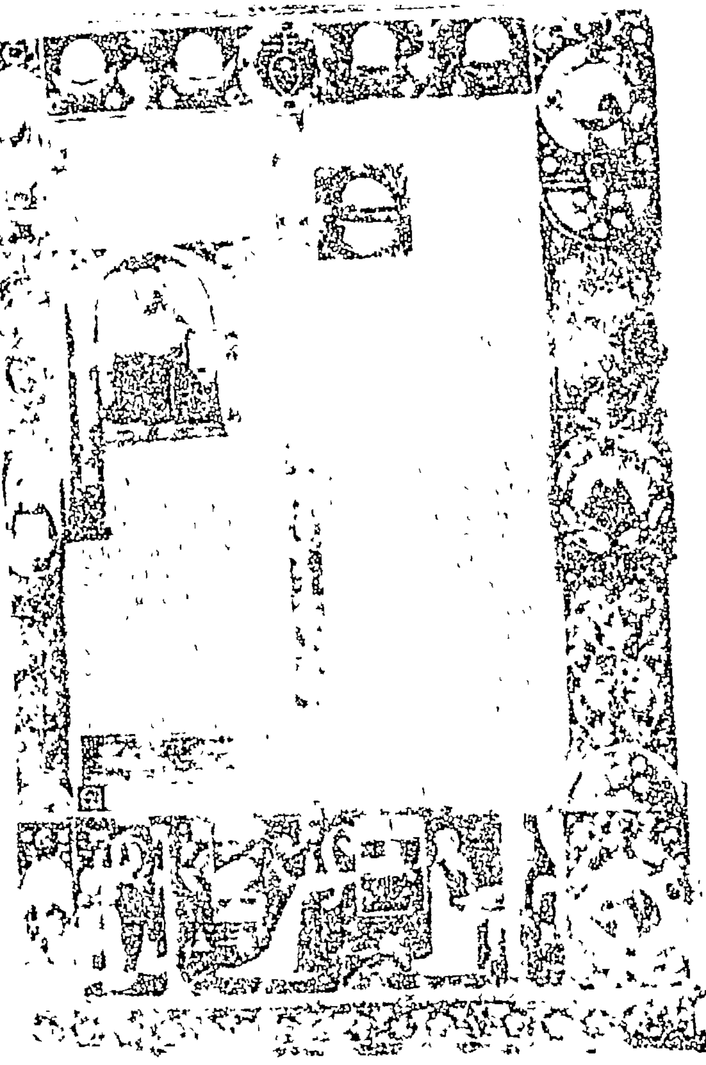
Considering the decorative sense of the Mesopotamians and their highly developed artistic skill, it would be strange if they did not imitate the Egyptians in decorating the pages of their manuscripts with colors

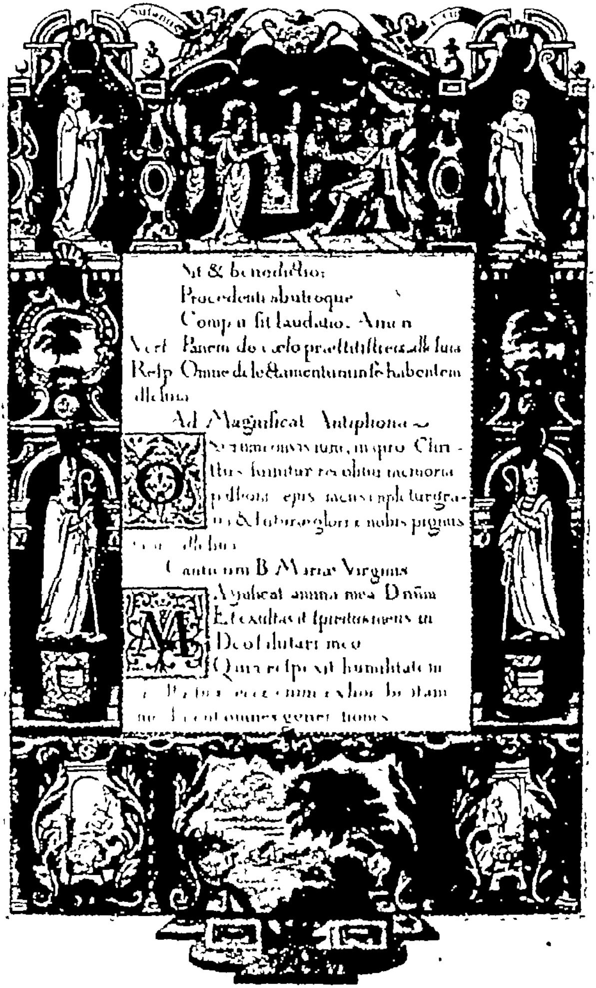
Such a suggestion, however, is purely conjectural, and it must be admitted that in the main the terra-cotta books that have come down to us in such profusion from Nineveh are quite without decoration of any sort. They serve the purpose of recording words and nothing more.

There are exceptional tablets, however, that present pictures which include not merely human figures, but decorative designs It will be recalled that one such was shown in an early plate of the present work As to the

PRAYER-BOOK OF DUKE OF BEDFORD (A.D. 1423-30)

QUEEN ISABELLA'S BREVIARY (A D 1497)




Sit & benedictio:
Procedenti ab utroque
Compar sit laudatio. Amen
Vers. Panem de caelo praestitisti eis alleluia
Resp. Omne delectamentum in se habentem alleluia
Ad Magnificat Antiphona
O sacrum convivium, in quo Christus sumitur, recolitur memoria passionis ejus, mens impletur gratia, & futurae gloriae nobis pignus datur alleluia
Canticum B. Mariae Virginis
Magnificat anima mea Dominum
Et exultavit spiritus meus in Deo salutari meo
Quia respexit humilitatem ancillae suae: ecce enim ex hoc beatam me dicent omnes generationes

PRAYER-BOOK OF LOUIS XIV (1638-1715)

books of Greece and Rome of the classical period, we are left equally in the dark, so far as direct evidence is concerned, since, as we have already seen, no such books have been preserved There may be certain significance in the fact that the Egyptian papyri of the Ptolemaic and Roman periods which have given us our oldest examples of Greek bookmaking are quite without decoration. Still, one must not draw too sweeping inferences from examples that, after all, are so fragmentary in comparison with the vast stores that have been destroyed

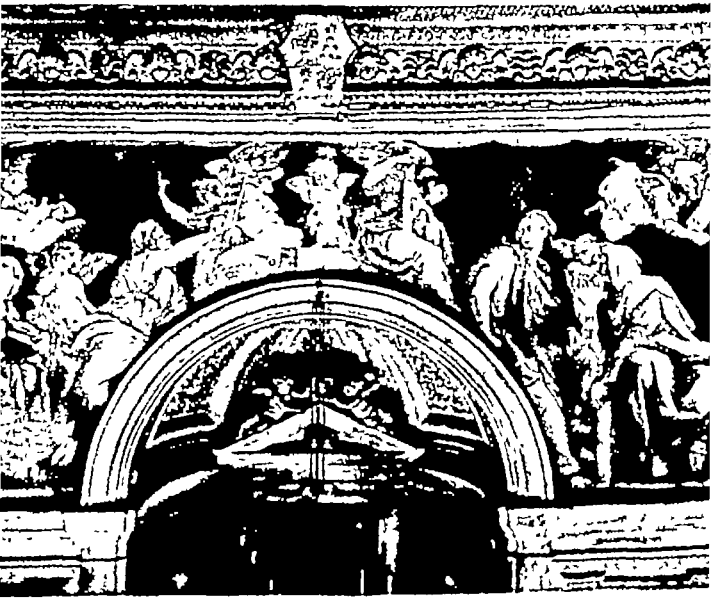
A single item of positive testimony here, as in many other cases, would outweigh any amount of negative evidence, and the remark of Pliny that books existed in Rome illustrated with portraits of celebrities, furnishes such an item most unequivocally Nevertheless, it is much to be regretted that no examples of the book illustrations of this early period have been preserved

The oldest decorative manuscripts, aside from the Egyptian ones, already mentioned, date from about the fourth century A D From that time on illuminated books become more and more abundant The art was practised extensively at Constantinople throughout the period of Byzantine greatness, and long before the Eastern Empire was overthrown, the art of illuminating books had become fashionable in the West, and it so continued until the sixteenth century, being practised extensively for a long time after printing came into vogue

A glance at our illustrations will give a better idea than any number of descriptions of the varying degrees of skill and the changing tastes with which this art was practised century after century Attention should be given also, in this connection, to the decorative initials reproduced from ancient manuscripts

A complete series of illuminated books supplies the

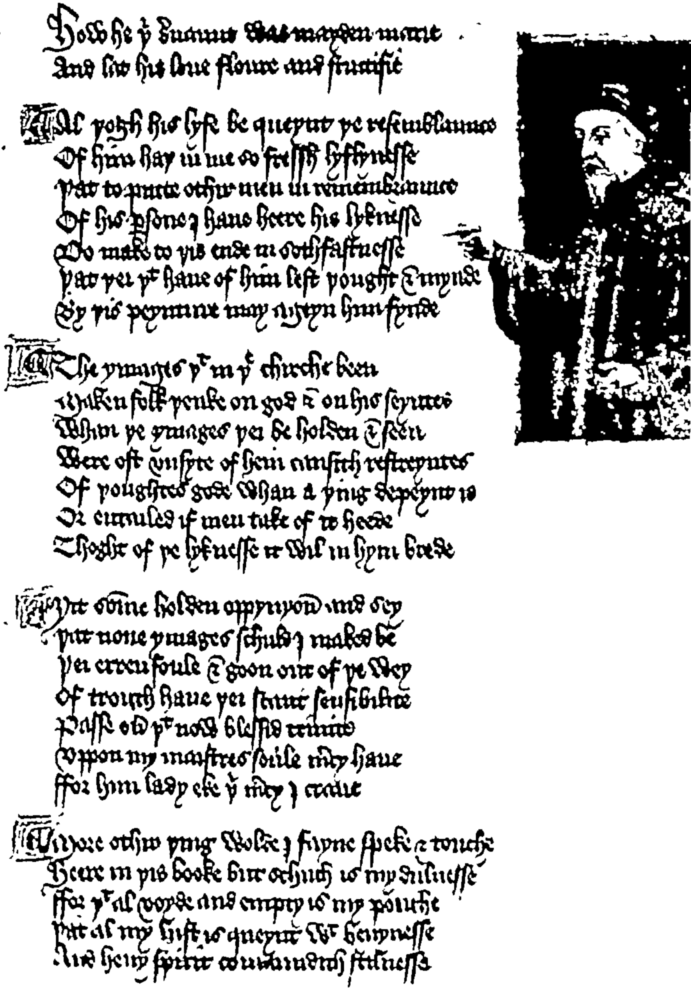
fullest account that has been preserved of the history of art and of costume throughout the Middle Ages Unfortunately, a great proportion of these illuminated books are copies of the Scriptures and of such allied writings as breviaries, prayer books, and the lives of saints These give, of course, indefinite scope to the artist in the matter of decoration, but the choice of subject is more restricted, and therefore the historical value of the manuscript is smaller than if a more catholic taste had been in vogue



THE FOUR SIBYLS, BY RAPHAEL (1483-1520)

BOOK II

THE POLITICAL AND ECONOMIC BACKGROUND


How he þi seruaunt was mayden marie
And lat his loue floure and fructifie

Al þogh his lyfe be queynt þe resemblaunce
Of him haþ in me so fressh lyflynesse
Þat to putte oþir men in remembraunce
Of his persone I haue heere his lyknesse
Do make to þis ende in soþfastnesse
Þat þei þat haue of him lest þought & mynde
By þis peynture may ageyn him fynde

The ymages þat in þe chirche been
Maken folk þenke on god & on his seyntes
Whan þe ymages þei beholden & seen
Were oft vnsyte of hem causiþ restreyntes
Of þoughtes gode whan a þing depeynt is
Or entailed if men take of it heede
Thoght of þe lyknesse it wil in hem brede

Yit some holden opynyoun and sey
Þat none ymages schuld I maked be
Þei erren foule & goon out of þe wey
Of trouþ haue þei scant sensibilite
Passe ouer þat now blessid trinite
Vppon my maistres soule mercy haue
For him lady eke þi mercy I craue

More oþir þing wolde I fayne speke & touche
Heere in þis booke but swich is my dulnesse
For þat al voyde and empty is my pouche
Þat al my lust is queynt wiþ heuynesse
And heuy spirit commaundiþ stilnesse

POEM BY THOMAS OCCLEVE, WITH PORTRAIT OF CHAUCER (EARLY 15TH CENTURY)

I

ITALY IN THE DARK AGE

IT has been observed again and again that the sweep of history is a continuous stream, and that all attempts to divide it into epochs are more or less arbitrary Nevertheless, one cannot escape the tendency to classify, and memory is greatly aided by such arbitrary divisions The largest and perhaps the most uniformly accepted form of such arbitrary parceling out of history is the classification into ancient, medieval, and modern

Everyone is aware that the general historian usually regards ancient history as closing either with the later decades of the fourth century, when the northern barbarians began their invasions, or, perhaps more generally, with the precise date 476, when the last emperor of old Rome was dethroned

The ensuing epoch, comprising a period of about a thousand years, is known as the medieval period, which epoch is usually considered as closing with the discovery of the New World in 1492

The earlier centuries of this epoch are usually spoken of as constituting the dark age

Such a division is arbitrary, but not altogether illogical. It has been urged that Rome itself did not know it had fallen in the year 476; and that the Roman Empire — even the Roman Republic, in the phrasing of the time — went on, as the minds of contemporaries conceived it, uninterruptedly for many centuries after the date which we of later time fix for the quietus of Roman imperial life

But few things are better established than the fact that a clear conception of history demands opportunity for the observation of events in perspective. In other words, a contemporary judgment is rarely, if ever, the best judgment regarding any epoch In the multiplicity of details that are thrust necessarily upon the attention of the contemporary observer, large proportions are lost, and a confused mass of little things makes the picture as unintelligible as is the large canvas of the painter when viewed at too short a focus.

With the historical view, as with the painting, one must recede to a certain distance before gaining a measurably true conception

And so, looking back through the vista of centuries, one is able to observe very clearly that the time of the alleged fall of the Western Roman Empire was a time of real crisis in the sweep of historical events. The erection of the one focal date is, to be sure, a quite unjustifiable marking of boundary lines, unless it be regarded in the same way in which one thinks of the parallels of latitude and longitude on the globe.

It is a convenient milestone, nothing more

But the epoch which it marks, if not to be limited to the confines of a single year, is none the less a true epoch: as no one can doubt who will consider the history of Rome in the aggregate during the first, second, and third centuries of the Christian era, and then will consider the history of the same city during the fifth, sixth, and seventh centuries

Obviously, a vast change has come over the spirit of civilization in this time, the later centuries, contrasted with the earlier ones, may well be considered a dark age.

During its period the eastern division of the later Roman Empire was the seat of a culture which found ex-

pression in the production of an elaborate literature But the West was under quite different auspices.

Rome had ceased to be important as a center of civilization; its chief citizens had removed to the city of Constantinople Here in the West the half-civilized Herulians and Ostrogoths held almost undisputed sway from 476 till about the middle of the sixth century Then for a century the Eastern Empire reasserted control over Rome, and the legions of Narses and Longinus upheld the authority of the Byzantine emperors. But in 568 the Lombards under Alboin swept down into Italy, and their supremacy was hardly disputed until the Carlovingians took a hand in Italian affairs, with the result that in 774 Charlemagne, capturing Desiderius in Pavia, assumed the title of king of the Lombards and virtually ended the Lombard kingdom

In 781 Charlemagne crowned his son Pepin king of Italy, and in the memorable year 800 Charlemagne was himself crowned Emperor of the West, reviving the title and a semblance of the glory of the old Imperium.

Charlemagne's successors retained nominal control over the empire, and disputed with the popes the real control of Italy This warfare between the papal monarch and the emperors was a salient feature of the later centuries of the epoch. The power of the church had increased slowly and insidiously until the ninth and tenth centuries the bishop of Rome aspired to real kingship over Italy — even over the entire empire

The five hundred years of Italian history outlined in this period contrast strangely in their world-historical meaning with the half-millennium of empire that preceded it, or with the other half-millennium within which were comprised the events of the Roman commonwealth. Those earlier periods, as we glance back over them in

perspective, bristle with great events; whereas this later epoch shows a bare plane of mediocrity, if not of decline

Yet we must not think of these later centuries as representing a time of relapse into actual barbarism It was rather an epoch when the decadent civilization was struggling against complete overthrow, while the new civilization was striving to make itself felt — striving as yet ineffectually as regards the higher culture, yet none the less preparing the way for the future germination of a new life in the old empire

There is no more fascinating effort open to the historian than to glance back through the mists of the centuries and attempt to penetrate the gloom of this dark age, and visualize its social conditions At best such an attempt at reconstructing the distant past can be but partially successful If it be true that "we view the world through our own eyes, each of us, and make from within us the things we see," as Thackeray tells us regarding our contemporary environment, vastly more distorted must our image be of any past events

Where the monuments, art treasures, and literature of a great civilization have been preserved to us, as in the case of Egypt and Mesopotamia and Greece and Rome, we have aids and accessories for the reconstruction of the picture that enable us to view our rehabilitation with a certain confidence. But where these mementoes of the past are lost or altogether lacking, the picture must, indeed, be vague and uncertain—the foggy tracery of the impressionist as contrasted with the firm outlines of a Michelangelo

And such are the disadvantages that beset the task of reconstructing the image of Italy, or indeed of any other part of Europe, in the so-called dark age It was a time when the wealth of the later empire had been trans-

ferred to the East. Western Europe was poverty-stricken; and this practical fact, perhaps more than any other one cause, operated to prevent the construction of such monuments of architecture and of art as the earlier centuries achieved

It is hardly more than a truism to say that the seat of the greatest civilization is almost sure to be the commercial and monetary center of the world. This was to be illustrated again with renewed force at a later day in Italy, when the gold of the Florentine tradesmen, the Medici, stimulated the art development of the Renaissance

But in those post-imperial times Italy had no wealth in commerce, as compared with the new center of the empire in Constantinople Such Romans as remained in Italy were too poor to build palaces and amphitheaters comparable to those of their predecessors. They had enough to do to guard themselves against the invaders from the north. At best they could hardly repair the structures that the earlier civilization had left them.

We read that in Venice it was at one time made a legal offense, punishable with a fine of one thousand florins, to suggest any draft on the public treasury for repairing state buildings. According to the familiar tradition, the doge who finally had the temerity to violate the restriction came before the council with the thousand florins in his hand when making the suggestion. This story illustrates the financial stress under which the Italian cities labored even at a comparatively late period of the Middle Ages.

But it would be a very great mistake to suppose that the lapse in the material civilization which undoubtedly took place in the later day of imperial Rome coincided with an entire change in the social conditions of the

people No trait in human nature is more fixed and more insistent than the tendency to cling to the ways of our forbears Conservatism is the dominant motive of the mass of humanity What our fathers thought and believed, we for the most part think and believe The average man inherits his religion and his politics much as he inherits the color of his eyes, and has scarcely more likelihood of changing one than the other In the sweep of the centuries, ideas and customs do change, to be sure, but the changes, in so far as they pertain to longstanding principles or customs, are always slow and gradual.

Geologists of the nineteenth century demonstrated, after long study and much argument, that there are no cataclysmic vaults in the sweep of the geological and biological ages The lesson thus taught regarding nature at large is one which the sociologist might apply to his own would-be science with advantage In particular this lesson should be called to the attention of the student of history who would have us believe that there was a sudden and catastrophic change in the mentality of the people of Italy in the fifth century A D No one who appreciates the true character of human progress will be disposed to believe, in the absence of confirmatory evidence, that the Italian of the sixth century differed very greatly in his desires and aspirations from his grandparent who lived while Rome was yet nominally governed by an Italian emperor.

The successive hordes of barbarians that swept down from the north took booty wherever they could find it, and impoverished the country, but for the most part they were not imbued with the spirit of wanton destruction We may well believe that they looked rather with awestruck admiration akin to reverence upon the wonderful monuments of a civilization so different from any-

thing they had ever seen We know that relatively civilized nations of the north sacked Rome in the sixteenth century more disastrously than it was sacked by their alleged barbaric precursors of the earlier millennium

Moreover, these invaders from the north were not omnipresent They came and went at relatively long intervals, and there were some territories that they did not greatly molest And the history of invasions everywhere goes to show that after the moment of initial conquest the barbaric vanquisher becomes, in matters of custom and thought, a follower rather than a leader of the vanquished

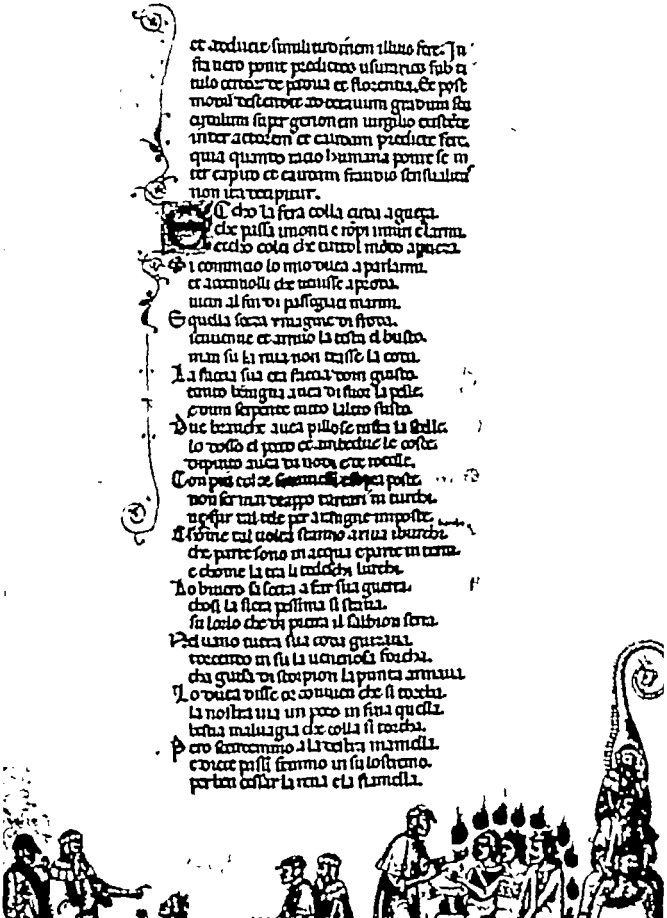
In the present case there can be no doubt that this rule held true The nations of the north were gifted with potentialities that were rapidly developed through imitation of the southern civilization Long before the so-called dark age ended, there began to be centers of civilization in the north, and here and there a man of real genius a Roger Bacon or an Abelard– appeared to prove the rapid forward sweep of the culture movement, since the highest genius never towers far above the culture level of its time But this could not have come to pass if the invader from the north had entered Italy as an all-devastating eliminator of previous civilizations. He came to conquer, but he remained to learn the arts of civilization.

In a word, then, we shall gain a truer picture of the state of Italy in the so-called dark age if we think of it as differing not so greatly in the ideals of its material civilization from the Italy of the Roman Empire. There is no great architecture, no great art, no great literature; but we cannot believe that there were absolutely no aspirations toward these antique ideals When we recall how much that was known to be produced in the earlier

day has been utterly lost, we need not doubt that there were some productions even in the field of literature, of which we now have no knowledge, that we would gladly reclaim from oblivion

The *cacoethes scribendi* is too dominant an impulse to be quite absent from any generation. surely, human nature did not change so utterly in the dark age as to rout this impulse from the human mind What chiefly did occur, apparently, was the direction of the literary impulse into an unfortunate channel—the channel of ecclesiasticism This carried it to a maelstrom from which the would-be producer of literature was not able to disengage himself for many generations A startling evidence of this is found in the fact that, as Robinson points out, there was no literary layman of renown from Boetius (d 524 or 525 A.D.) to Dante (1265-1321 A D)

Let us think, then, of the dark age as a time when Italy was impoverished, a time when its material civilization retrogressed; a time when the stress of new conditions thrust some of the old ideals into the background, but also as a time when the mixture of races was taking place that was to give new strength and fiber to a senescent people, and to make possible the resuscitation of the old ideals, the rehabilitation of the old material civilization, the regeneration of the race



THE *DIVINE COMEDY*, WITH PICTURE OF DANTE, VIRGIL, AND THE BEAST (14TH CENTURY)

II

SIGNS OF AWAKENING

THE regeneration was not to be effected, however, for some time to come The eleventh and the twelfth centuries were at best to see only the dawning of the new day Creative culture was still in abeyance in Italy. There were still no writers of significance; there was little art except as practised in the illumination of manuscripts and as foreshadowed in the beginnings of a new architecture

Nevertheless, there was a germinative culture. Here and there a knight brought back à book from the East – for this was the age of the Crusades Here and there a monk pored over a classic manuscript Virgil was read and copied all through the dark age, as we know from the incontestable evidence of extant manuscripts

There was no manuscript of Horace in the uncial writing of the early centuries, yet he too must have been read in the West, along with all the other Latin classics that have come down to us, else these works would scarcely have been preserved, for the Greek authors alone found favor in the East.

Still it is to be feared that the chief interest felt by many of the monks in the old-time manuscripts was directed toward the material on which they were written rather than toward the text itself. Hagiology often took the place of history, and many an ancient manuscript has been preserved in palimpsest merely because a monk who wished to write the life of a saint was too careless to complete the erasure of the earlier writing

Contemplating the monastic life, through which it is often asserted the germs of learning were preserved in the western world in this dark age, one receives an impression of racial stasis which does not really accord with the facts. If the monks were the preservers of the feeble torch of learning, it was the wandering and warring hosts of the outside world who were preparing their generation to receive the new light when it should again burst forth

The Scandinavian and German hosts from the north invaded Italy en masse, from time to time, and successive bands of Crusaders made Italy their highway when journeying to and from the East Many of these invaders found the southern climate congenial and took up their permanent abode there Thus the Normans established a kingdom in Italy, and if the other hosts settled as individuals rather than as nations, their influence must have been none the less potent in bringing about that mixture of racial elements which makes for racial progress

Equally important must have been the influence of the commercial spirit The conquest of the Normans took from the Greek cities of southern Italy—Amalfi, Naples, and Gaeta— the commercial supremacy they had previously enjoyed. They were superseded by Pisa, Genoa, and Venice. These cities kept fleets on the sea in constant contact with the East As might have been expected, they led other Italian cities in power and influence, and were the first to show intimations of that quickening of life which presaged the new birth.

The first half of the thirteenth century furnished additional chapters in the old story of the fight between emperor and pope. Frederick II, the incumbent of the imperial throne, was one of the most picturesque charac-

ters of the Middle Ages. He was a man of extraordinary versatility, master of many languages, including Greek and Arabic, patron of the arts, himself a poet, and what perhaps is most remarkable of all, considering his scholarly proclivities, an advocate of the use of the vernacular out of which a new Italian language was developing.

Frederick was far too versatile a man to be confined within the boundaries of the church, hence his life was made up of a series of wrangles with the popes. Yet he upheld the religious liberties of his subjects in Sicily, he prosecuted a successful Crusade, and restored the influence of the western world in Jerusalem. He was under ban of excommunication when he undertook this Crusade, and later he was denounced for having undertaken it.

He rebelled against the papal antagonism, and declared that he would wear his crown and uphold its authority despite ecclesiastical interference.

Similar threats had been pronounced before, and even so powerful an emperor as Henry IV failed to make good his menace. But Frederick adopted a novel plan which for a time proved expedient, he colonized Lucera with a population of Saracens, which could furnish him a band of thirty thousand Moslem warriors to whom papal authority meant nothing.

Notwithstanding this aid, however, he was barely able to hold his own against the pope in the long run, and he died just at the middle of the century, worn out in middle life by endless warrings.

During the ensuing half-century Italy was little troubled by the emperors, papal authority was at its height, but a disunited Italy consumed its strength in internal dissensions. The developing civilization had

gradually focalized more and more toward the north, and now its center had come to be Tuscany—the same geographical location which furnished the pre-Roman civilization of the Etruscans

Florence came to be the chief city of Tuscany; it was the chief center also of one of the most persistent and disastrous of the strifes that were confusing Italy, —the warfare of the Guelfs and Ghibellines

This dissension was in no sense confined to Florence, to be sure, it included all Italy and even extended beyond the national bounds The factions warred with varying success In 1260 the Guelfs at Florence met with a signal reverse at the battle of Monteaperto. But eight years later at Theliacozza, the Ghibellines under Conradin, the last of the Hohenstaufens, received a most disastrous setback

An important feature of the epoch was the steady development of a half-dozen cities; in particular the rivalry between the three chief maritime cities, Venice, Pisa, and Genoa Pisa had more than held her own hitherto, but in 1284 she received her quietus in the duel with Genoa off the isle of Meloria; henceforth she yielded supremacy to her conqueror and to Venice.

But, as has been said, the maritime cities no longer held uncontested supremacy. Florence, "The Flower of Tuscany," tho lacking the advantage of geographical position, was able, nevertheless, to take a place among the commercial centers. Thanks to her location on the highway between Germany and southern Italy, she perhaps profited more by that all-essential mingling of the races to which reference has been made, than any of her sister cities. Just at the close of the thirteenth century the warfare of the Guelfs and Ghibellines received a new development in Florence through the strife of the fac-

tions that come to be known as the Whites and Blacks. the dispute which began as a mere personal strife spread its baneful influence over the entire community.

Notwithstanding all these dissensions, however, there was marked progress in civilization during this century The Italian cities could boast that their streets were paved, while the streets of Paris, the foremost city of the north, were mere beds of mud The growing desire for education was evidenced in the founding of schools and universities in Italy Just at the close of the century the since famous Palazzo Vecchio and the even more famous Santa Croce were constructed In the field of pictorial art there were also evidences of the new plane of culture to which Italy had attained, while scholarship found a worthy exponent in the celebrated Thomas Aquinas

III

PROGRESS IN THE FOURTEENTH CENTURY

FOR about a half-century Italy had been free from the intrusions of the emperors, but early in the fourteenth century Henry VII crossed the Alps. Unlike some of his predecessors, he met a rather hearty welcome from several of the cities and from the pope. The Florentines, on the other hand, did not welcome him, and his coming led to the usual turmoils His sudden death—perhaps from poison—dissipated all the hopes based on the imperial presence. His successor, Louis of Bavaria, also came to Italy and in association with the great general Castruccio made war upon the Florentines, who had been forced much against their will to put themselves under the leadership of the Duke of Naples.

The Florentines held their own fairly well against the outside invaders, but found themselves unable to tolerate the tyranny within their walls. They ended by expelling the tyrant

A striking feature of the century is the abandonment of Rome by the popes, who retired to Avignon for more than seventy years—from 1305 to 1377—an interval famous ever since as the Babylonish captivity During the absence of the popes the Romans fared but ill. Lacking the papal power which made their city a center of world influence, they were given over to minor dissensions. The famous Rienzi—"The last of the tribunes"—made a heroic effort to restore order just at the middle of the century, and for a time dominated the situation,

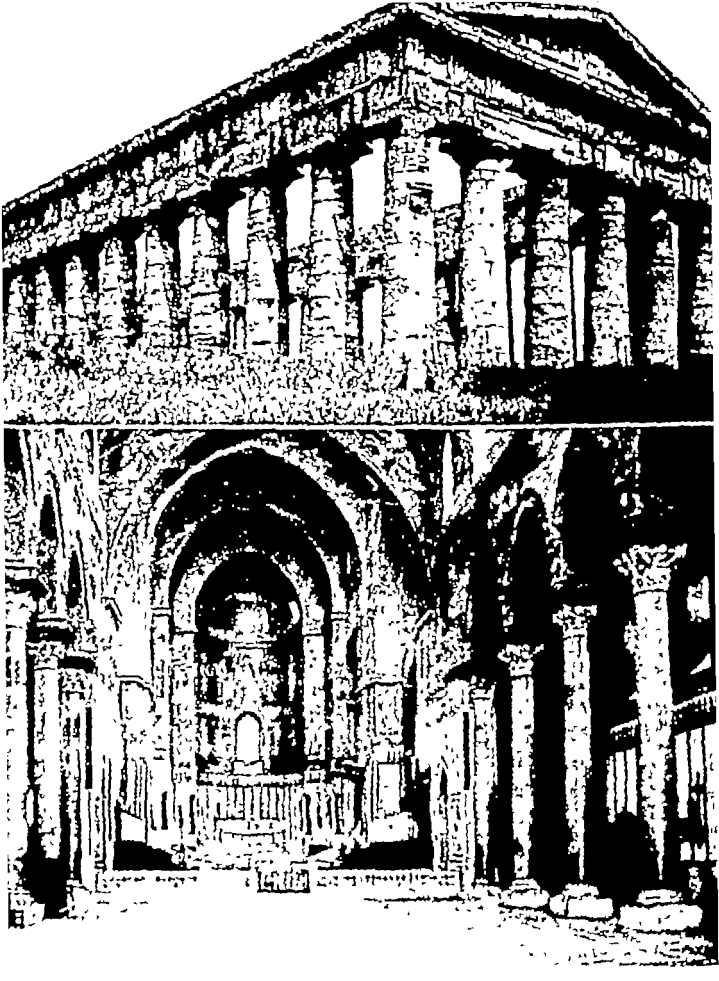
only to be overthrown ingloriously after a brief period of authority

In the north the Visconti made themselves dominant in Milan and interfered perpetually in general politics, striving to subordinate all Italy to their influence Florence was brought into repeated conflicts with the successive rulers of this family, and it was in these contests that the great English general, Sir John Hawkwood, came to the fore

Leader of a band of mercenaries—soldier of fortune in the most literal sense of the word—this famous warrior fought first against the Florentines, and subsequently in their service Despite some reverses he gained a reputation which led Hallam to consider him the first great commander since Roman times This estimate perhaps does Hawkwood something more than justice; it overlooks the great Castruccio, to go no further But undoubtedly Hawkwood was a redoubtable leader, and he was among the first of a series of *condottieri* who gave distinction to Italian armies during the ensuing century

Genoa and Venice were drawn into a disastrous warfare; in fact, the various dominant cities of Italy were almost perpetually quarreling. Even the great plague which swept over Italy in 1348, despite its devastations —so graphically described by Boccaccio—served to give scarcely more than a temporary lull to the dissensions The insurrection of the Ciompi, the Great Schism, and the outbreak of the war of Chioggia are dissensions that mark the later decades of the century.

But all these political dissensions sink quite into insignificance in comparison with the tremendous intellectual development of the time As we have seen, the western world has been preparing for centuries for the development of an indigenous culture Now the promise



GREEK TEMPLE AT GIRGENTI

CATHEDRAL OF MONREALE (12TH CENTURY)

meets fruition. It required but the waft of a breeze from the East to fan the smouldering embers into flame. This vivifying influence came about partly through the emigration of large numbers of scholars from Constantinople; a migration incited chiefly by fear of the Turks. These scholars brought with them their love of the Greek classics and stimulated the nascent scholarship of Italy into a like enthusiasm.

Soon there began and developed a great fashion of searching for classical manuscripts, and many half-forgotten authors were brought to light. It became the fashion to copy these manuscripts, as every gentleman's house must now have a library. The revival of interest came about in time to save more than one classical author from oblivion, whose works would probably have perished utterly had they been subjected to another century of neglect. Such an author as Velleius Paterculus, for example, is known exclusively through a single manuscript, which obviously must have escaped destruction through mere chance; and everyone is aware how large a proportion of classical writers were not accorded even this measure of fortune. No doubt many authors were inadvertently allowed to perish even after this revival of interest, but the number must have been very small in proportion to those that were already lost.

But the revival of interest in the works of antiquity was by no means the greatest literary feature of the time There came with it a creative impulse which gave the world the works of Dante, Petrarch, and Boccaccio, not to mention the lesser chroniclers. Their work evidenced that spontaneous outbreak of the creative impulse for which the classicism of the East had been preparing. How spontaneous it was, how little understood, even by its originators, is illustrated in the fact that both Dante,

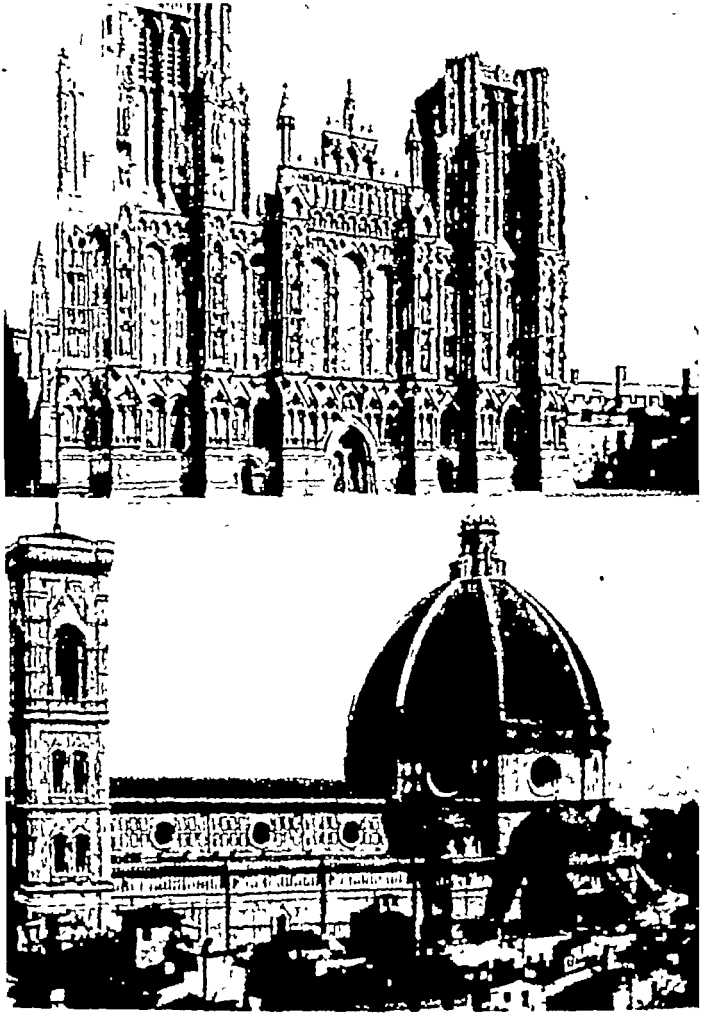
the creator of Italian poetry, and Boccaccio, the creator of Italian prose, regarded their work in the vernacular as relatively unimportant; basing their hopes of immortality upon their archaic Latin treatises, which the world promptly forgot. No better illustration could be furnished anywhere of that spontaneity of truly creative art to which we have had occasion more than once to refer.

Nor was it in literature alone that the time was creative. Pictorial art had likewise its new beginning in this epoch. Cimabue, indeed, had made an effort to break with the crude traditions of the eastern school of art in the latter part of the thirteenth century; his greater pupil Giotto developed his idea in the early decades of the fourteenth century, and gathered by him, the school of painters in Florence attempted, following their master, to go to nature and to reproduce what they saw.

Their effort was a crude and tentative one, judged according to the canons of the later development; but it was the beginning of great things.

In architecture the effort of the time was not doomed to be content with mere beginnings: "Giotto's tower," the famous Campanile, still stands in evidence of the relative perfection to which this department of art had attained.

All in all, then, the fourteenth century was a time of wonderful development in Italy; the clarion note of Dante has been called the voice of ten silent centuries; it told of a new phase of the Renaissance



EARLY GOTHIC CATHEDRAL

GIOTTO'S TOWER AND DUOMO

IV

CLOSING SCENES OF THE MEDIEVAL EPOCH

DURING the fifteenth century Italy enjoyed a period of relative immunity from outside interference An emperor was crowned at Rome in the early days of the century, to be sure, and there were various efforts at interference by other powers, including the coming of Charles VIII in 1494 But, as a general thing, it was the Italians themselves who competed with one another, rather than outside powers who quarreled with Italy as a whole

The great forces were, as before, the few important cities These were forever quarreling one with another Pisa became subordinate to Florence, and the latter city waxed steadily in greatness. In Milan the rule of the Visconti continued till toward the middle of the century, when, on the disappearance of the last member of that important family, the house of Sforza came to the fore and took to itself the task of dictatorship In Naples King Ladislaus, and later Queen Joanna II, maintained regal influence and made their principality a world power. Thus in the middle of the century the four great powers were Naples, Milan, Venice, and Florence

In these wars the mercenary leaders were much in evidence These were men to whom fighting was simply a business — a means to a livelihood. No question of patriotism was involved in their warfare; they gave their services to the state that offered the most liberal pay-

ment in gold or its equivalent. Half a dozen of these men gained particular distinction in the fifteenth century. These were Braccio, Fortebraccio, Sforza Attendola, and his son Francesco Sforza, Carmagnola, Niccolo Piccinino, and Colleno Coleoni These men were variously matched against one another in the important wars.

Braccio and Sforza Attendola came into prominence in the papal wars, having to do with the Great Schism, and beginning about the close of the first decade of the fifteenth century Braccio fought for Florence, and Sforza at first for Pope John XXIII, and subsequently for King Ladislaus of Naples, who at this time was the strongest ruler in Italy This war concerned most of the powers of Italy, and involved Anjou and France as well. The death of Ladislaus helped to terminate the conflict, but at the same time precipitated a new war, by raising the question of succession to the throne of Naples.

In this war of the Neapolitan succession Fillipo Maria, duke of Milan, upheld the cause of the house of Anjou, while Florence sided with Alfonzo The chief scene of the war was in the north, where the forces of Milan and Naples competed with those of Florence and Venice

It was here that Carmagnola (born Francesco Dussone) was given the opportunity to show his genius as a leader. He served first under Fillipo, but subsequently entered the service of Venice and acquired new honors as the opponent of his old employer.

After the settlement of this war of the Neapolitan succession Fillipo Maria was soon embroiled again, this time with Pope Eugenius. The pope took refuge in Florence, and the Tuscans, again supported by Venice, upheld him. Francesco Sforza now fought for the Florentines, his opponent, the leader of the Visconti's army, being Niccolo Piccinino. But before the war was over

the Visconti had gained Sforza back again. On the death of Fillipo the Milanese established a republic, avowing that they would never again submit to a tyrant. But necessity soon drove them to call on Francesco Sforza to aid them in a war against Venice, and their successful general presently usurped power and established a new line of tyrants

In the later wars between Milan and Venice Colleno Coleoni appeared, and after bartering his services first to one party and then to the other, became permanently established as generalissimo of the land forces of Venice in 1454

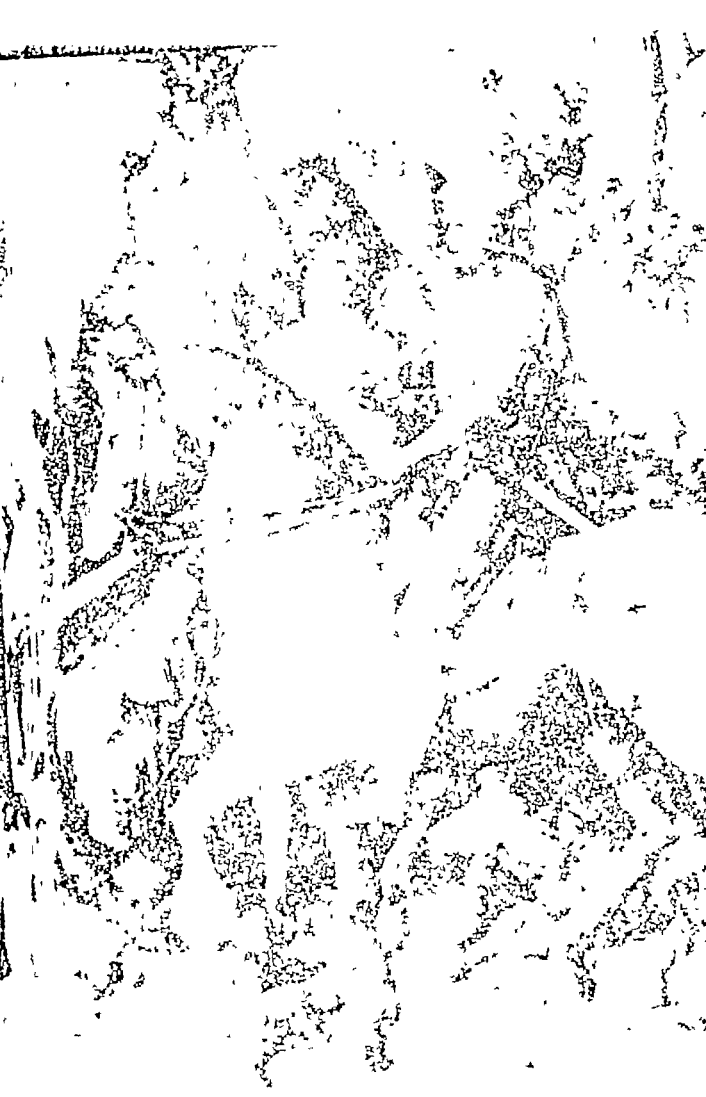
One of the most striking features of this warfare was that it came to nothing So many rival interests were involved, so kaleidoscopic were the shiftings of the various leaders, so utterly lacking in any great central cause of contention, that it is sometimes almost impossible to say where one war ends and another begins. Each petty state is thinking of its own interests And the only thing approaching a general principle of action is the fear on the part of each state that any other single state might gain too much influence over Italy as a whole

In other words the thought of maintaining a balance of power was in the mind of all such leaders as had no hope of making themselves supreme.

As Florence at no time had a hope of becoming politically dominant, her efforts were always directed toward maintaining a balance of power, and where personalities did not enter into the matter, she tended in the main to champion the cause of the weaker party

But despite the interest which necessarily attaches to all these political jarrings, the really world-historical importance of Florentine history during this period had to do not with wars, but with the marvelous internal cul-

DÜRER VISITS HANS SACHS



ture development. Already in the van of the Renaissance movement, Florence held her proud position securely throughout the fifteenth century, and was incontestably the culture center of the world.

This was the age of the Medici. It was then that Cosmo the Great and Lorenzo the Magnificent made their influence felt, and enjoyed practical dictatorship, tho the form of government continued a democracy. The real source of Florentine influence was the old familiar one—commercial prosperity.

Florence in the previous century had produced such men as Dante, Petrarch, Boccaccio, and Giotto. The intellectual supremacy thus evidenced was maintained in the ensuing century, but the early part of that century had no names to show that are comparable to these in artistic greatness The stamp of the times, at least of the first half of the fifteenth century, was industrial rather than artistic This was the time when the gradually increasing commercial importance of Italy had culminated in unequivocal world supremacy. Venice and Florence were now the business centers of the world.

In Florence various forms of craftsmanship had attained a degree of importance which made them famous for all time

The gilds of woolen weavers, of cloth merchants, of silk weavers, and of money-changers had become institutions of world-wide influence. The money lenders of Florence were found plying their trade in every capital of Europe. Despite their extortions they were regarded everywhere as a necessary evil; and Florentine gold in this century exercised an influence almost as wide as the quondam influence of Roman arms. The Florentine money-changer held almost unchallenged the position that the Jew occupied at a later day.

Oddly enough, it may be noted that the Jew himself was barred from plying the trade of money lender in Florence until about the end of the first third of the fifteenth century, when, paradoxical as it may seem, he was legally granted the privilege to protect the borrower from the extortions of the native usurers of the city.

The rapid development of commerce and industry brought with it, not unnaturally, a great change in the habits of the Florentine people. Early in the century the houses in Florence were still simple and relatively plain in their equipment The windows were barred by shutters, glass not being yet in common use; the stairways are narrow, the entrances unostentatious. But before the close of the century all this was changed. The power of wealth made itself felt in the houses, equipments, and costumes of the people, in their luxurious habits of living; their magnificent banquets and demonstrations, and all that goes to make up a life of sensuous pleasure.

Most significant of all, however, was the influence which wealth had enabled one family to attain; for the power of the Medici was, in its essentials, the power of gold. It was a power wielded deftly in the hands of prominent representatives of the family; a power that seemed to make for the good of the city.

Under Lorenzo the Magnificent every form of art was patronized and cultivated, and Florence easily maintained its supremacy as the culture center of Italy. Such sculptors as Donatello, Verrocchio, and their fellows; such painters as Filippo Lippi, Botticelli, and Ghirlandajo, not to mention a varied company of only lesser attainments; and a company of distinguished workmen in all departments of the lesser arts, lent their influence to beautify the city under the patronage of Lorenzo

The school of art thus founded was to give the world

such names as Michelangelo and Raphael in the succeeding generations

Curiously enough, by some unexplained oversight, the greatest painter of the century, Leonardo da Vinci, was led to make his greatest efforts in Milan and not in Florence during the life of Lorenzo, tho he returned to the latter city not long after the death of the great patron of art.

As a patron of literature Lorenzo was no less active He founded and developed a wonderful library in which the treasures of antiquity were collected, in the original or in copies, regardless of expense, from all parts of Europe The art of bookmaking was carried to its highest development in this period The manuscripts of the time are marvels of beauty. The ornamentation is beautiful, and the letters themselves are printed with a degree of regularity closely rivaling the uniformity of a printed page

And then not long after the middle of the century, just when this art of the scribe was at its height, the printing-press was introduced from Germany, and an easy mechanical means was at hand by which the most perfect technique could be attained

True, the connoisseur did not at first recognize the printed book as a possible rival of the old hand-made work. For a long time the collector continued to employ the hand workman, and the dilettante looked upon the printed book with much the same scornful glance which the modern collector of paintings bestows upon a chromo or lithograph.

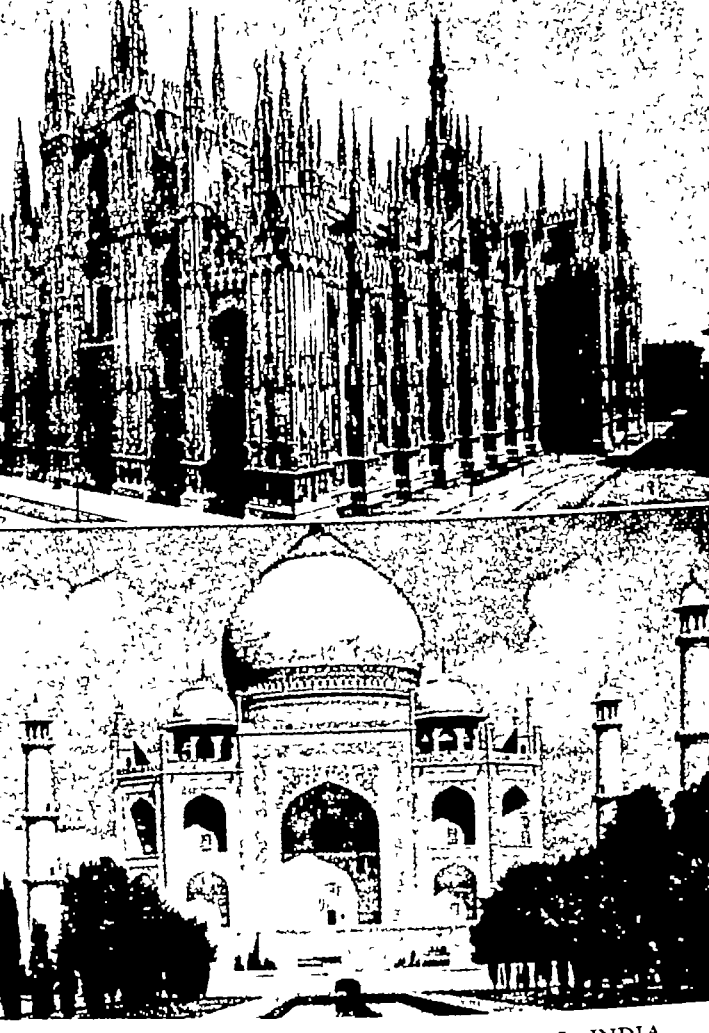
The first Italian printing-press was set up, according to Von Reumont, at Subiaco in a Benedictine monastery in 1465. Some fifteen years later Vespasiano da Bisticci, writing about the library of the Duke of Urbino, could

proudly state that "All the volumes are of the most faultless beauty, written by hand, with elegant miniatures, and all on parchment. There are no printed books among them, the duke would have been ashamed to have them."

Notwithstanding the scornful attitude of the connoisseur, however, the art of printing books made its way rapidly. Hitherto the cost of production had rendered even the most ordinary book a luxury not to be possessed by any but the relatively wealthy. Naturally enough, an eager band of book lovers hailed the advent of the new method, despite its supposed artistic shortcomings; and before the end of the century there were printing-presses in all the important centers of Italy, and numberless classics, beginning with Virgil, had been given a vastly wider currency than had ever previously been possible. It is needless to dwell upon the remoter influences of this rapid diffusion of classical treasures, but nowhere was the influence more important than in Italy.

Summarizing in a few words the influences of the fifteenth century in Italy, it may be repeated that, as a whole, it was an epoch of industrial and commercial progress rather than of the greatest art The culminating achievements of the century, the invention of the printing-press and the discovery of America were not Italian triumphs; tho as the birthplace of Columbus and the home of Amerigo Vespucci, Italy cannot well be denied a share in the finding of the New World

Indeed, the association of Italy with this great achievement is perhaps closer than might at first sight appear. For it is held that the geographical work of Toscanelli was directly instrumental in stimulating Columbus to the conception of a western passage to India, while, in another view, the influence of the spirit of exploration



MILAN CATHEDRAL — THE TAJ MAHAL, INDIA

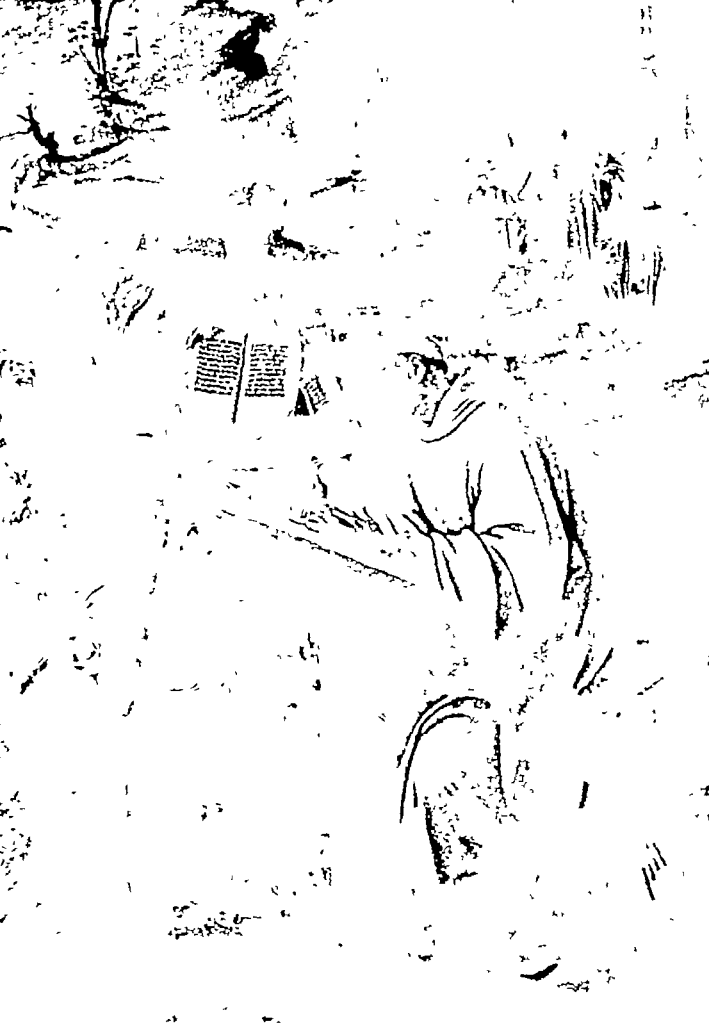
and discovery fostered by the commercial relations of Italy in making possible the feat of Columbus, must have been inestimable.

Be all that as it may, the discovery of the New World — made in the last decade of the century, and, as it chanced in the same year in which Lorenzo de' Medici died—may well be considered not merely as a culminating achievement of the century, but as symbolical of that commercial and industrial spirit for which the century is chiefly remarkable.

We have now advanced to the date which is usually named as closing the medieval epoch, but what has been said about the arbitrary character of this classification should be borne in mind. The discovery of America in 1492 did indeed mark the beginning of a new era in one sense, since it opened up a new hemisphere to the observation and residence of civilized man.

That discovery, too, prepared the way for the demonstration of the fact that the world is round; hence it became an important cornerstone in the building of that new structure of man's conception of cosmology of which the master builders were Copernicus, Kepler, Galileo, and Newton.

But the building of this new structure—a revolutionizing of man's conception of the cosmos—did not come about in a year or a century.



THE VIRGIN APPEARS TO ST BERNARD
FILIPPINO LIPPI

V

THE AGE OF GREAT ARTISTS

THE sixteenth century was a time of peculiar contrasts in Italy. The invasions which began with the coming of Charles VIII in 1494 continued and became more and more harassing Italy came to be regarded as the proper prey of the French and Spanish rulers The Italian principalities, warring as ever with one another, welcomed or repelled the invaders in accordance with their own selfish interests

All this time there had been no unified government of Italy as a whole Nominally the empire included all, but this was a mere theory which, for the most part, would not bear examination

Venice all along claimed allegiance to the Eastern Empire, which since the middle of the fifteenth century had ceased to exist.

Florence owed no allegiance to any outside power; it was strictly autonomous. The democratic feeling was still strong there notwithstanding the usurpations of the Medici.

Venice and Florence with Siena and Lucca were the only republics remaining at the beginning of the sixteenth century. Of the scores of cities which formerly were republics, all the rest had come under the influence of tyrants, or had been brought into unwilling subordination to neighboring cities.

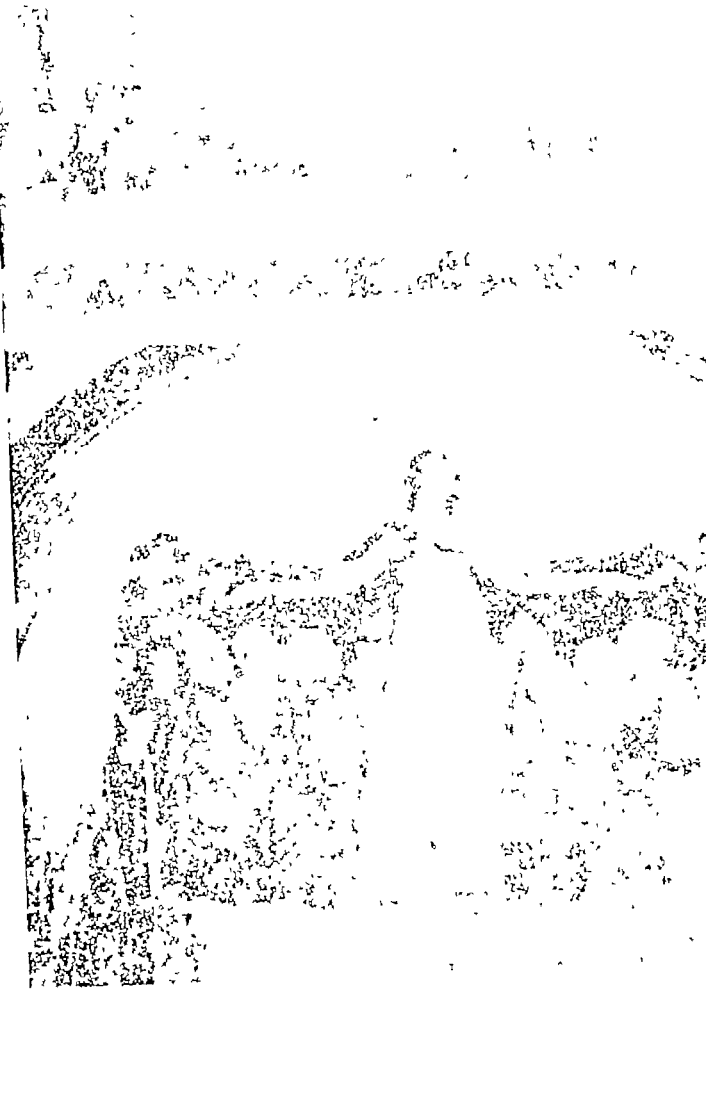
And now an even greater humiliation was in store for many of them at the hands of the transalpine conquerors.

Venice, recovering from her duel to the death with Genoa—the war of Chioggia—continued to hold closely to her old traditions. Her commercial prosperity continued for a time, but was gradually lessened through the loss of eastern territories and through the rivalry brought about by the discovery of America and of a sea route to India

Florence, having thrown off in 1494 the thraldom imposed by the Medici, made spasmodic efforts to return to the old purely democratic system, but failed in the end In 1569 Cosmo de' Medici was made Grand Duke of Tuscany, a position which his successors continued to hold for seven generations (till 1737). In a word, the spirit of democracy was virtually dead in Italy, and as yet no local tyrant arose who had the genius to unite the petty principalities into a unified kingdom

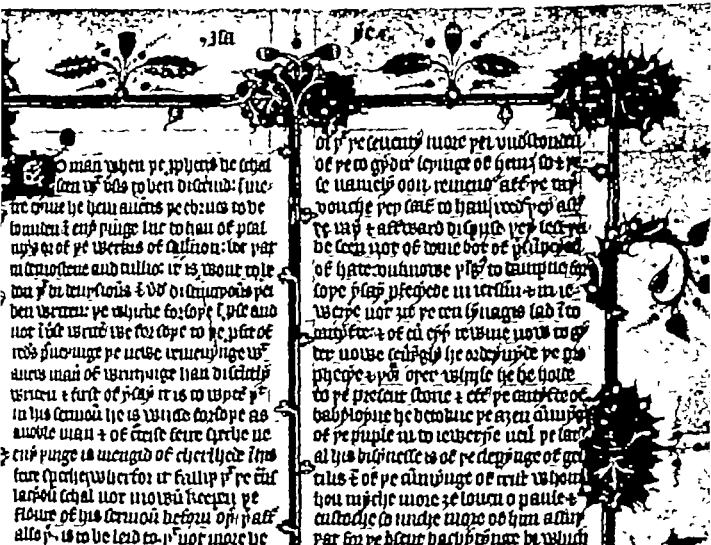
But if political Italy was chaotic and unproductive in this century, the case was quite different when we consider the civilization of the time. The vivifying influences of the previous century produced a development, particularly in the field of art, which showed great results. The early decades of the sixteenth century constituted an epoch of the greatest art development in Italy. This was the age of Leonardo, of Michelangelo, of Raphael, and of Titian, and of the host of disciples of these masters Under the patronage of successive popes, the master painters were stimulated to their best efforts, and those wonderful decorations of the Vatican were undertaken which have been the delight of all later times.

The literary development, if it did not quite keep pace with the pictorial, nevertheless attained heights which it had only once before reached since classical times All this culture development in a time of turmoil and political disaster seems anomalous, and, as just in-



timated, can only be explained as the fruitage of a development which had its origin in an earlier epoch The validity of this explanation is illustrated in the rapid decline that took place in Italy after the middle of the sixteenth century—an intellectual decline which was scarcely to be interrupted until the nineteenth century

Such, then, was the political milieu in the midst of which the intellectual development of the Renaissance took place Let us now turn to another aspect of the development of this period of transition from medieval to modern times



MS OF WYCLIF'S BIBLE, 14TH CENTURY

BOOK III

THE NEW ERA OF SCIENCE

THE LAST JUDGMENT MICHELANGELO'S GREAT MURAL IN THE VATICAN

I

THE NEW COSMOLOGY—COPERNICUS TO KEPLER AND GALILEO

WE have seen that the Ptolemaic astronomy, which was the accepted doctrine throughout the Middle Ages, taught that the earth is round. Doubtless there was a popular opinion current which regarded the earth as flat, but it must be understood that this opinion had no champions among men of science during the Middle Ages When, in the year 1492, Columbus sailed out to the west on his memorable voyage, his expectation of reaching India had full scientific warrant, however much it may have been scouted by certain ecclesiastics and by the average man of the period Nevertheless, we may well suppose that the successful voyage of Columbus, and the still more demonstrative one made about thirty years later by Magellan, gave the theory of the earth's rotundity a certainty it could never previously have had

Alexandrian geographers had measured the size of the earth, and had not hesitated to assert that by sailing westward one might reach India. But there is a wide gap between theory and practise, and it required the voyages of Columbus and his successors to bridge that gap.

After the companions of Magellan completed the circumnavigation of the globe, the general shape of our earth would, obviously, never again be called in question. But demonstration of the sphericity of the earth had, of course, no direct bearing upon the question of the earth's

position in the universe. Therefore the voyage of Magellan served to fortify, rather than to dispute, the Ptolemaic theory

According to that theory, as we have seen, the earth was supposed to lie immovable at the center of the universe; the various heavenly bodies, including the sun, revolving about it in concentric circles We have seen that several of the ancient Greeks, notably Aristarchus, disputed this conception, declaring for the central position of the sun in the universe, and the motion of the earth and other planets about that body. But this revolutionary theory seemed so opposed to the ordinary observation that, having been discountenanced by Hipparchus and Ptolemy, it did not find a single important champion for more than a thousand years after the time of the last great Alexandrian astronomer.

The first man, seemingly, to hark back to the Aristarchian conception in the new scientific era that was now dawning was the noted cardinal, Nikolaus of Cusa, who lived in the first half of the fifteenth century, and was distinguished as a philosophical writer and mathematician His *De Docta Ignorantia* expressly propounds the doctrine of the earth's motion. No one, however, paid the slightest attention to his suggestion, which, therefore, merely serves to furnish us with another interesting illustration of the futility of propounding even a correct hypothesis before the time is ripe to receive it—particularly if the hypothesis is not fully fortified by reasoning based on experiment or observation.

The man who was destined to put forward the theory of the earth's motion in a way to command attention was born in 1473, at the village of Thorn, in eastern Prussia His name was Nicholas Copernicus

There is no more famous name in the entire annals of

science than this, yet posterity has never been able fully to establish the lineage of the famous expositor of the true doctrine of the solar system. The city of Thorn lies in a province of that border territory which was then under control of Poland, but which subsequently became a part of Prussia. It is claimed that the aspects of the city were essentially German, and it is admitted that the mother of Copernicus belonged to that race. The nationality of the father is more in doubt, but it is urged that Copernicus used German as his mother-tongue. His great work was, of course, written in Latin, according to the custom of the time, but it is said that, when not employing that language, he always wrote in German.

The disputed nationality of Copernicus strongly suggests that he came of a mixed racial lineage, and we are reminded again of the influences of those ethnical minglings to which we have previously more than once referred. The acknowledged centers of civilization toward the close of the fifteenth century were Italy and Spain. Therefore, the birthplace of Copernicus lay almost at the confines of civilization, reminding us of that earlier period when Greece was the center of culture, but when the great Greek thinkers were born in Asia Minor and in Italy.

As a young man, Copernicus made his way to Vienna to study medicine, and subsequently he journeyed into Italy and remained there many years. About the year 1500 he held the chair of mathematics in a college at Rome. Subsequently he returned to his native land and passed his remaining years there, dying at Domkerr, in Frauenburg, East Prussia, in the year 1543.

It would appear that Copernicus conceived the idea of the heliocentric system of the universe while he was a comparatively young man, since in the introduction to

his great work, which he addressed to Pope Paul III., he states that he has pondered his system not merely nine years, in accordance with the maxim of Horace, but well into the fourth period of nine years Throughout a considerable portion of this period the great work of Copernicus was in manuscript, but it was not published until the year of his death. Copernicus undoubtedly taught his system throughout the later decades of his life. He himself tells us that he had even questioned whether it were not better for him to confine himself to such verbal teaching, following thus the example of Pythagoras Just as his life was drawing to a close, he decided to pursue the opposite course, and the first copy of his work is said to have been placed in his hands as he lay on his deathbed

The violent opposition which the new system met from ecclesiastical sources led subsequent commentators to suppose that Copernicus had delayed publication of his work through fear of the church authorities There seems, however, to be no direct evidence for this opinion It has been thought significant that Copernicus addressed his work to the pope It is, of course, quite conceivable that the aged astronomer might wish by this means to demonstrate that he wrote in no spirit of hostility to the church. His address to the pope might have been considered as a desirable shield precisely because the author recognized that his work must needs meet with ecclesiastical criticism. Be that as it may, Copernicus was removed by death from the danger of attack, and it remained for his disciples of a later generation to run the gantlet of criticism and suffer the charges of heresy.

The work of Copernicus, published thus in the year 1543 at Nuremberg, bears the title *De Orbium Cœlestium Revolutionibus*

It is not necessary to go into details as to the cosmological system which Copernicus advocated, since it is familiar to every one. In a word, he supposed the sun to be the center of all the planetary motions, the earth taking its place among the other planets, the list of which, as known at that time, comprised Mercury, Venus, the Earth, Mars, Jupiter, and Saturn. The fixed stars were alleged to be stationary, and it was necessary to suppose that they are almost infinitely distant, inasmuch as they showed to the observers of that time no parallax; that is to say, they preserved the same apparent position when viewed from the opposite points of the earth's orbit.

This fact had been regarded as an important argument against the motion of the earth, and it was still so considered by the opponents of the system of Copernicus It had, indeed, been necessary for Aristarchus to explain the fact as due to the extreme distance of the stars; a perfectly correct explanation, but one that implies distances that are altogether inconceivable. It remained for nineteenth-century astronomers to show, with the aid of instruments of greater precision, that certain of the stars have a parallax. But long before this demonstration had been brought forward, the system of Copernicus had been accepted as a part of common knowledge

While Copernicus postulated a cosmical scheme that was correct as to its main features, he did not altogether break away from certain defects of the Ptolemaic hypothesis Indeed, he seems to have retained as much of this as practicable, in deference to the prejudice of his time Thus he records the planetary orbits as circular, and explains their eccentricities by resorting to the theory of epicycles, quite after the Ptolemaic method But now, of course, a much more simple mechanism sufficed to

explain the planetary motions, since the orbits were correctly referred to the central sun and not to the earth.

Needless to say, the revolutionary conception of Copernicus did not meet with immediate acceptance. A number of prominent astronomers, however, took it up almost at once, among these being Rhæticus, who wrote a commentary on the evolutions; Erasmus Reinhold, the author of the Prutenic tables; Rothmann, astronomer to the Landgrave of Hesse, and Maestlin, the instructor of Kepler. The Prutenic tables, just referred to, so called because of their Prussian origin, were considered an improvement on the tables of Copernicus, and were highly esteemed by the astronomers of the time The commentary of Rhæticus gives us the interesting information that it was the observation of the orbit of Mars and of the very great difference between his apparent diameters at different times which first led Copernicus to conceive the heliocentric idea. Of Reinhold it is recorded that he considered the orbit of Mercury elliptical, and that he advocated a theory of the moon, according to which her epicycle revolved on an elliptical orbit, thus in a measure anticipating one of the great discoveries of Kepler to which we shall refer presently.

The Landgrave of Hesse was a practical astronomer, who produced a catalog of fixed stars which has been compared with that of Tycho Brahe. He was assisted by Rothmann and by Justus Byrgius. Maestlin, the preceptor of Kepler, is reputed to have been the first modern observer to give a correct explanation of the light seen on portions of the moon not directly illumined by the sun. He explained this as not due to any proper light of the moon itself, but as light reflected from the earth. Certain of the Greek philosophers, how-

ever, are said to have given the same explanation, and it is alleged also that Leonardo da Vinci anticipated Maestlin in this regard.

While various astronomers of some eminence thus gave support to the Copernican system almost from the beginning, it unfortunately chanced that by far the most famous of the immediate successors of Copernicus declined to accept the theory of the earth's motion. This was Tycho Brahe, one of the greatest observing astronomers of any age Tycho Brahe was a Dane, born at Knudstrup in the year 1546. He died in 1601 at Prague, in Bohemia. During a considerable portion of his life he found a patron in Frederick, King of Denmark, who assisted him to build a splendid observatory on the Island of Hveen. On the death of his patron Tycho moved to Germany, where, as good luck would have it, he came in contact with the youthful Kepler, and thus, no doubt, was instrumental in stimulating the ambitions of one who in later years was to be known as a far greater theorist than himself.

As has been said, Tycho rejected the Copernican theory of the earth's motion. It should be added, however, that he accepted that part of the Copernican theory which makes the sun the center of all the planetary motions, the earth being excepted. He thus developed a system of his own, which was in some sort a compromise between the Ptolemaic and the Copernican systems. As Tycho conceived it, the sun revolves about the earth, carrying with it the planets Mercury, Venus, Mars, Jupiter, and Saturn, which planets have the sun and not the earth as the center of their orbits. This scheme may be made to explain the observed motions of the heavenly bodies, but it involves a much more complex mechanism than is postulated by the Copernican theory.

Various explanations have been offered of the conservatism which held the great Danish astronomer back from full acceptance of the relatively simple and, as we now know, correct Copernican doctrine. From our latter-day point of view, it seems so much more natural to accept than to reject the Copernican system, that we find it difficult to put ourselves in the place of a sixteenth-century observer. Yet if we recall that the traditional view, having warrant of acceptance by nearly all thinkers of every age, recorded the earth as a fixed, immovable body, we shall see that our surprize should be excited rather by the thinker who can break away from this view than by the one who still tends to cling to it.

Moreover, it is useless to attempt to disguise the fact that something more than a mere vague tradition was supposed to support the idea of the earth's overshadowing importance in the cosmical scheme. The sixteenth-century mind was overmastered by the tenets of ecclesiasticism, and it was a dangerous heresy to doubt that the Hebrew writings, upon which ecclesiasticism based its claim, contained the last word regarding matters of science. But the writers of the Hebrew text had been under the influence of that Babylonian conception of the universe which accepted the earth as unqualifiedly central—which, indeed, had never so much as conceived a contradictory hypothesis; and so the Western world, which had come to accept these writings as actually supernatural in origin, lay under the spell of Oriental ideas of a pre-scientific era.

In our own day, no one speaking with authority thinks of these Hebrew writings as having any scientific weight whatever. Their interest in this regard is purely antiquarian; hence from our changed point of view it

CREATION OF ADAM MURAL BY MICHELANGELO

seems scarcely credible that Tycho Brahe can have been in earnest when he quotes the Hebrew traditions as proof that the sun revolves about the earth. Yet for almost three centuries after the time of Tycho, these dreamings continued to be cited in opposition to those scientific advances which new observations made necessary; and this notwithstanding the fact that the Oriental phrasing is, for the most part, poetically ambiguous and susceptible of shifting interpretations, as the criticism of successive generations has amply testified.

Tycho Brahe began his objections to the Copernican system by quoting the adverse testimony of a Hebrew prophet who lived more than a thousand years B.C. All this shows sufficiently that Tycho Brahe was not a great theorist. He was essentially an observer, but in this regard he won a secure place in the very first rank Indeed, he was easily the greatest observing astronomer since Hipparchus, between whom and himself there were many points of resemblance Hipparchus, it will be recalled, rejected the Aristarchian conception of the universe just as Tycho rejected the conception of Copernicus

But if Tycho propounded no great generalizations, the list of specific advances due to him is a long one, and some of these were to prove important aids in the hands of later workers to secure demonstration of the Copernican idea. One of his most important series of studies had to do with comets. Regarding these bodies there had been the greatest uncertainty in the minds of astronomers They were thought on one hand to be divine messengers, and on the other to be merely igneous phenomena of the earth's atmosphere. Tycho Brahe declared that a comet which he observed in the year 1577 had no parallax, proving its extreme distance The

observed course of the comet intersected the planetary orbits, which fact gave a quietus to the long-mooted question as to whether the Ptolemaic spheres were transparent solids or merely imaginary; since the comet was seen to intersect these alleged spheres, it was obvious that they could not be the solid substance that they were commonly imagined to be, and this fact in itself went far toward discrediting the Ptolemaic system. It should be recalled, however, that this supposition of tangible spheres for the various planetary and stellar orbits was a mediæval interpretation of Ptolemy's theory rather than an interpretation of Ptolemy himself, there being nothing to show that the Alexandrian astronomer regarded his cycles and epicycles as other than theoretical.

An interesting practical discovery made by Tycho was his method of determining the latitude of a place by means of two observations made at an interval of twelve hours. Hitherto it had been necessary to observe the sun's angle on the equinoctial days, a period of six months being therefore required. Tycho measured the angle of elevation of some star situated near the pole, when on the meridian, and then, twelve hours later, measured the angle of elevation of the same star when it again came to the meridian at the opposite point of its apparent circle about the pole-star. Half the sum of these angles gives the latitude of the place of observation.

As illustrating the accuracy of Tycho's observations, it may be noted that he rediscovered a third inequality of the moon's motion at its variation, he, in common with other European astronomers, being then quite unaware that this inequality had been observed by an Arabian astronomer. Tycho proved also that the angle of

inclination of the moon's orbit to the ecliptic is subject to slight variation.

The very brilliant new star which shone forth suddenly in the constellation of Cassiopeia in the year 1572, was made the object of special studies by Tycho, who proved that the star had no sensible parallax and consequently was far beyond the planetary regions. The appearance of a new star was a phenomenon not unknown to the ancients, since Pliny records that Hipparchus was led by such an appearance to make his catalog of the fixed stars. But the phenomenon is sufficiently uncommon to attract unusual attention A similar phenomenon occurred in the year 1604, when the new star—in this case appearing in the constellation of Serpentarius—was explained by Kepler as probably proceeding from a vast combustion. This explanation—in which Kepler is said to have followed Tycho—is fully in accord with the most recent theories on the subject.

It is surprizing to hear Tycho credited with so startling a theory, but, on the other hand, such an explanation is precisely what should be expected from the other astronomer named. For Johann Kepler, or, as he was originally named, Johann von Kappel, was one of the most speculative astronomers of any age. He was forever theorizing, but such was the peculiar quality of his mind that his theories never satisfied him for long unless he could put them to the test of observation. Thanks to this happy combination of qualities, Kepler became the discoverer of three famous laws of planetary motion which lie at the very foundation of modern astronomy and were to be largely instrumental in guiding Newton to his still greater generalization.

These laws of planetary motion were vastly important as corroborating the Copernican theory of the universe,

tho their position in this regard was not immediately recognized by contemporary thinkers. Let us examine with some detail into their discovery, meantime catching a glimpse of the life history of the remarkable man whose name they bear.

Johann Kepler was born the 27th of December, 1571, in the little town of Weil, in Württemberg. He was a weak, sickly child, further enfeebled by a severe attack of small-pox. It would seem paradoxical to assert that the parents of such a genius were mismated, but their home was not a happy one, the mother being of a nervous temperament, which perhaps in some measure accounted for the genius of the child. The father led the life of a soldier, and finally perished in the campaign against the Turks. Young Kepler's studies were directed with an eye to the ministry. After a preliminary training he attended the university at Tübingen, where he came under the influence of the celebrated Maestlin and became his life-long friend.

Curiously enough, it is recorded that at first Kepler had no taste for astronomy or for mathematics. But the doors of the ministry being presently barred to him, he turned with enthusiasm to the study of astronomy, being from the first an ardent advocate of the Copernican system. His teacher, Maestlin, accepted the same doctrine, tho he was obliged, for theological reasons, to teach the Ptolemaic system, as also to oppose the Gregorian reform of the calendar

The Gregorian calendar, it should be explained, is so called because it was instituted by Pope Gregory XIII, who put it into effect in the year 1582, up to which time the so-called Julian calendar, as introduced by Julius Cæsar, had been everywhere accepted in Christendom. This Julian calendar was a great improvement on pre-

ceding ones, but still lacked something of perfection inasmuch as its theoretical day differed appreciably from the actual day. In the course of fifteen hundred years, since the time of Cæsar, this defect amounted to a discrepancy of about eleven days. Pope Gregory proposed to correct this by omitting ten days from the calendar, which was done in September, 1582. To prevent similar inaccuracies in the future, the Gregorian calendar provided that once in four centuries the additional day to make a leap-year should be omitted, the date selected for such omission being the last year of every fourth century. Thus the years 1500, 1900, and 2300, A.D., would not be leap-years. By this arrangement an approximate rectification of the calendar was effected, tho even this does not make it absolutely exact.

Such a rectification as this was obviously desirable, but there was really no necessity for the omission of the ten days from the calendar. The equinoctial day had shifted so that in the year 1582 it fell on the 10th of March and September. There was no reason why it should not have remained there. It would greatly have simplified the task of future historians had Gregory contented himself with providing for the future stability of the calendar without making the needless shift in question. We are so accustomed to think of the 21st of March and 21st of September as the natural periods of the equinox, that we are likely to forget that these are purely arbitrary dates for which the 10th might have been substituted without any inconvenience or inconsistency.

But the opposition to the new calendar, to which reference has been made, was not based on any such considerations as these. It was due, largely at any rate, to the fact that Germany at this time was under sway

of the Lutheran revolt against the papacy. So effective was the opposition that the Gregorian calendar did not come into vogue in Germany until the year 1699. It may be added that England, under stress of the same manner of prejudice, held out against the new reckoning until the year 1751, while Russia did not accept it until our own day.

As the Protestant leaders thus opposed the papal attitude in a matter of so practical a character as the calendar, it might perhaps have been expected that the Lutherans would have had a leaning toward the Copernican theory of the universe, since this theory was opposed by the papacy. Such, however, was not the case. Luther himself pointed out with great strenuousness, as a final and demonstrative argument, the fact that Joshua commanded the sun and not the earth to stand still; and his followers were quite as intolerant toward the new teaching as were their ultramontane opponents.

Kepler himself was, at various times, to feel the restraint of ecclesiastical opposition, tho he was never subjected to direct persecution, as was his friend and contemporary, Galileo. At the very outset of Kepler's career there was, indeed, question as to the publication of a work he had written, because that work took for granted the truth of the Copernican doctrine. This work appeared, however, in the year 1596. It bore the title *Mysterium Cosmographium*, and it attempted to explain the positions of the various planetary bodies.

Copernicus had devoted much time to observation of the planets with reference to measuring their distance, and his efforts had been attended with considerable success. He did not, indeed, know the actual distance of the sun, and, therefore, was quite unable to fix the distance of any planet; but, on the other hand, he de-

termined the relative distance of all the planets then known, as measured in terms of the sun's distance, with remarkable accuracy.

With these measurements as a guide, Kepler was led to a very fanciful theory, according to which the orbits of the five principal planets sustain a peculiar relation to the five regular solids of geometry. His theory was this: "Around the orbit of the earth describe a dodecahedron — the circle comprising it will be that of Mars; around Mars describe a tetrahedron—the circle comprising it will be that of Jupiter; around Jupiter describe a cube—the circle comprising it will be that of Saturn; now within the earth's orbit inscribe an icosahedron—the inscribed circle will be that of Venus; in the orbit of Venus inscribe an octahedron—the circle inscribed will be that of Mercury."

Tho this arrangement was a fanciful one, which no one would now recall had not the theorizer obtained subsequent fame on more substantial grounds, yet it evidenced a philosophical spirit on the part of the astronomer which, misdirected as it was in this instance, promised well for the future. Tycho Brahe, to whom a copy of the work was sent, had the acumen to recognize it as a work of genius. He summoned the young astronomer to be his assistant at Prague, and no doubt the association thus begun was instrumental in determining the character of Kepler's future work. It was precisely the training in minute observation that could avail most for a mind which, like Kepler's, tended instinctively to the formulation of theories. When Tycho Brahe died, in 1601, Kepler became his successor. In due time he secured access to all the unpublished observations of his great predecessor, and these were of inestimable value to him in the progress of his own studies.

Kepler was not only an ardent worker and an enthusiastic theorizer, but he was an indefatigable writer, and it pleased him to take the public fully into his confidence, not merely as to his successes, but as to his failures. Thus his works elaborate false theories as well as correct ones, and detail the observations through which the incorrect guesses were refuted by their originator. Some of these accounts are highly interesting, but they must not detain us here.

For our present purpose it must suffice to point out the three important theories which, as culled from among a score or so of incorrect ones, Kepler was able to demonstrate to his own satisfaction and to that of subsequent observers. Stated in a few words, these theories, which have come to bear the name of Kepler's Laws, are the following:

1. That the planetary orbits are not circular, but elliptical, the sun occupying one focus of the ellipses

2. That the speed of planetary motion varies in different parts of the orbit in such a way that an imaginary line drawn from the sun to the planet—that is to say, the radius vector of the planet's orbit—always sweeps the same area in a given time

These two laws Kepler published as early as 1609. Many years more of patient investigation were required before he found out the secret of the relation between planetary distances and times of revolution which his third law expresses. In 1618, however, he was able to formulate this relation also, as follows:

3. The cubes of the distance of the various planets from the sun are proportional to the squares of their periods of revolution about the sun

All these laws, it will be observed, take for granted the fact that the sun is the center of the planetary orbits

It must be understood, too, that the earth is constantly regarded, in accordance with the Copernican system, as being itself a member of the planetary system, subject to precisely the same laws as the other planets. Long familiarity has made these wonderful laws of Kepler seem such a matter of course that it is difficult now to appreciate them at their full value. Yet it was the knowledge of these marvelously simple relations between the planetary orbits that laid the foundation for the Newtonian law of universal gravitation.

Contemporary judgment could not, of course, anticipate this culmination of a later generation. What it could understand was that the first law of Kepler attacked one of the most time-honored of metaphysical conceptions—namely, the Aristotelian idea that the circle is the perfect figure, and hence that the planetary orbits must be circular. Not even Copernicus had doubted the validity of this assumption.

That Kepler dared dispute so firmly fixed a belief, and one that seemingly had so sound a philosophical basis, evidenced the iconoclastic nature of his genius That he did not rest content until he had demonstrated the validity of his revolutionary assumption shows how truly this great theorizer made his hypotheses subservient to the most rigid inductions.

While Kepler was solving these riddles of planetary motion, there was an even more famous man in Italy whose championship of the Copernican doctrine was destined to give the greatest possible publicity to the new ideas. This was Galileo Galilei, one of the most extraordinary scientific observers of any age. Galileo was born at Pisa, on the 18th of February (old style), 1564. The day of his birth is doubly memorable, since on the same day the greatest Italian of the preceding

epoch, Michelangelo, breathed his last. Persons fond of symbolism have found in the coincidence a forecast of the transit from the artistic to the scientific epoch of the later Renaissance.

Galileo came of an impoverished noble family. He was educated for the profession of medicine, but did not progress far before his natural proclivities directed him toward the physical sciences. Meeting with opposition in Pisa, he early accepted a call to the chair of natural philosophy in the University of Padua, and later in life he made his home at Florence. The mechanical and physical discoveries of Galileo will claim our attention in another chapter. Our present concern is with his contribution to the Copernican theory.

Galileo himself records in a letter to Kepler that he became a convert to this theory at an early day. He was not enabled, however, to make any marked contribution to the subject, beyond the influence of his general teachings, until about the year 1610. The brilliant contributions which he made were due largely to a single discovery — namely, that of the telescope. Hitherto astronomical observations had been made with the unaided eye. Glass lenses had been known since the thirteenth century, but, until now, no one had thought of their possible use as aids to distant vision. The question of priority of discovery has never been settled. It is admitted, however, that the chief honors belong to the opticians of the Netherlands.

As early as the year 1590 the Dutch optician Zacharias Jensen placed a concave and a convex lens respectively at the ends of a tube about eighteen iches long, and used this instrument for the purpose of magnifying small objects—producing, in short, a crude microscope. Some years later, Johannes Lippershey, of whom not

much is known except that he died in 1619, experimented with a somewhat similar combination of lenses, and made the startling observation that the weather-vane on a distant church-steeple seemed to be brought much nearer when viewed through the lens. The combination of lenses he employed is that still used in the construction of opera-glasses; the Germans still call such a combination a Dutch telescope.

Doubtless a large number of experimenters took the matter up and the fame of the new instrument spread rapidly abroad. Galileo, down in Italy, heard rumors of this remarkable contrivance, through the use of which it was said "distant objects might be seen as clearly as those near at hand." He at once set to work to construct for himself a similar instrument, and his efforts were so far successful that at first he "saw objects three times as near and nine times enlarged." Continuing his efforts, he presently so improved his glass that objects were enlarged almost a thousand times and made to appear thirty times nearer than when seen with the naked eye.

Naturally enough, Galileo turned this fascinating instrument toward the skies, and he was almost immediately rewarded by several startling discoveries. At the very outset, his magnifying-glass brought to view a vast number of stars that are invisible to the naked eye, and enabled the observer to reach the conclusion that the hazy light of the Milky Way is merely due to the aggregation of a vast number of tiny stars

Turning his telescope toward the moon, Galileo found that body rough and earth-like in contour, its surface covered with mountains, whose height could be approximately measured through study of their shadows This was disquieting, because the current Aristotelian doctrine supposed the moon, in common with the

planets, to be a perfectly spherical, smooth body. The metaphysical idea of a perfect universe was sure to be disturbed by this seemingly rough workmanship of the moon.

Thus far, however, there was nothing in the observations of Galileo to bear directly upon the Copernican theory; but when an inspection was made of the planets the case was quite different. With the aid of his telescope, Galileo saw that Venus, for example, passes through phases precisely similar to those of the moon, due, of course, to the same cause Here, then, was demonstrative evidence that the planets are dark bodies reflecting the light of the sun, and an explanation was given of the fact, hitherto urged in opposition to the Copernican theory, that the inferior planets do not seem many times brighter when nearer the earth than when in the most distant parts of their orbits, the explanation being, of course, that when the planets are between the earth and the sun only a small portion of their illumined surfaces is visible from the earth

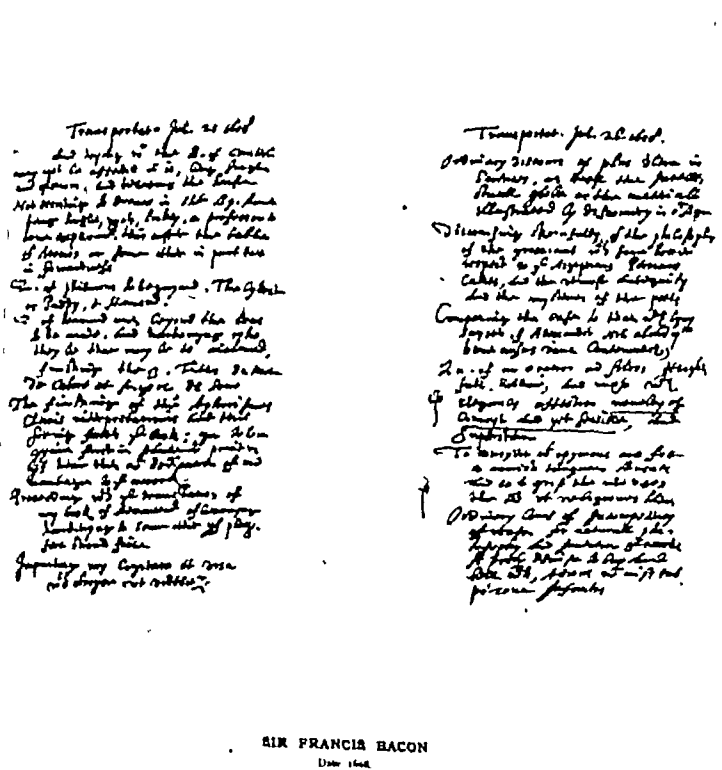
On inspecting the planet Jupiter, a still more striking revelation was made, as four tiny stars were observed to occupy an equatorial position near that planet, and were seen, when watched night after night, to be circling about the planet, precisely as the moon circles about the earth. Here, obviously, was a miniature solar system—a tangible object-lesson in the Copernican theory. In honor of the ruling Florentine house of the period, Galileo named these moons of Jupiter, Medicean stars

Turning attention to the sun itself, Galileo observed on the surface of that luminary a spot or blemish which gradually changed its shape, suggesting that changes were taking place in the substance of the sun—changes obviously incompatible with the perfect condition de

manded by the metaphysical theorists. But however disquieting for the conservative, the sun's spots served a most useful purpose in enabling Galileo to demonstrate that the sun itself revolves on its axis, since a given spot was seen to pass across the disk and after disappearing to reappear in due course. The period of rotation was found to be about twenty-four days.

It must be added that various observers disputed priority of discovery of the sun's spots with Galileo. Unquestionably a sun-spot had been seen by earlier observers, and by them mistaken for the transit of an inferior planet. Kepler himself had made this mistake. Before the day of the telescope, he had viewed the image of the sun as thrown on a screen in a camera-obscura, and had observed a spot on the disk which he interpreted as representing the planet Mercury, but which, as is now known, must have been a sun-spot, since the planetary disk is too small to have been revealed by this method. Such observations as these, however interesting, cannot be claimed as discoveries of the sun-spots. It is probable, however, that several discoverers (notably Johann Fabricius) made the telescopic observation of the spots, and recognized them as having to do with the sun's surface, almost simultaneously with Galileo. One of these claimants was a Jesuit named Scheiner, and the jealousy of this man is said to have had a share in bringing about that persecution to which we must now refer.

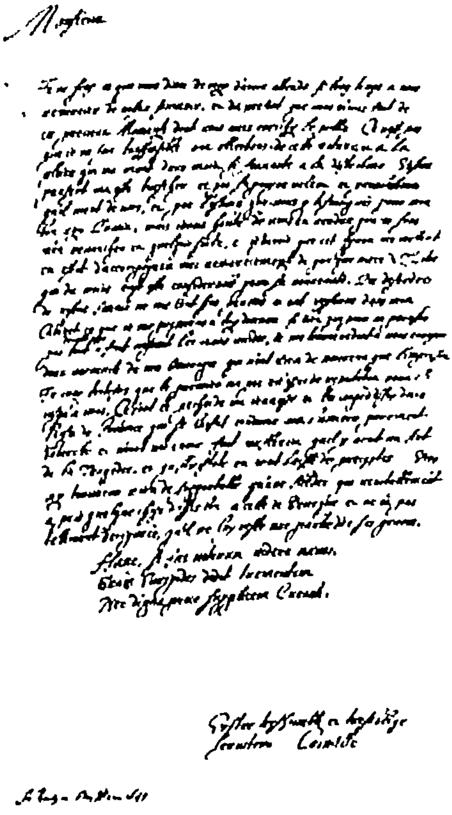
There is no more famous incident in the history of science than the heresy trial through which Galileo was led to the nominal renunciation of his cherished doctrines There is scarcely another incident that has been commented upon so variously. Each succeeding generation has put its own interpretation on it. The facts, however, have been but little questioned



SIR FRANCIS BACON

Date 1608

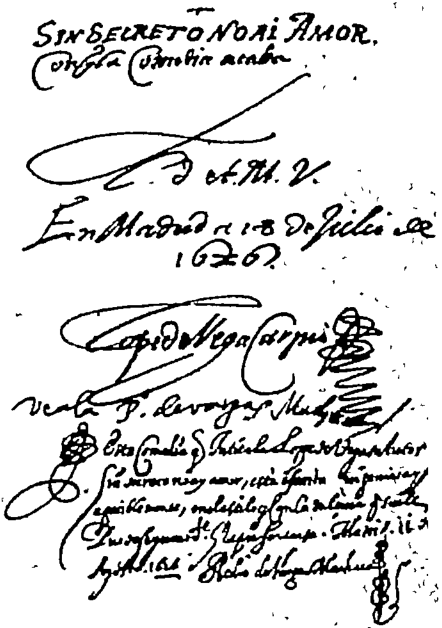
British Museum, Add Ms 27,278



PIERRE CORNEILLE.

(date 1649)

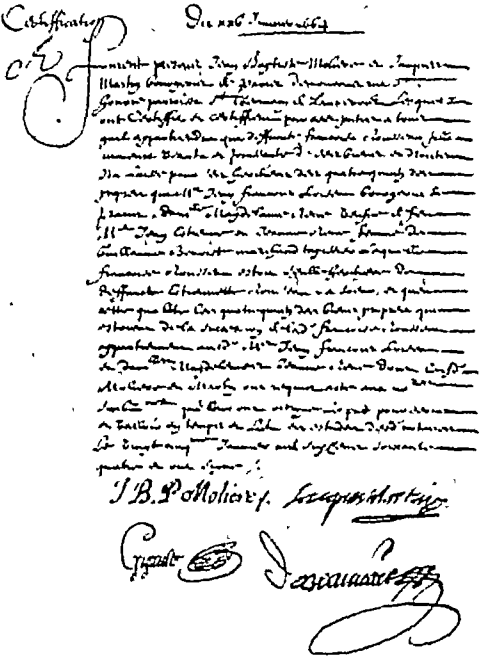
British Museum, Add. MS. 21,514.



LOPE FELIX DE VEGA CARPIO.

Date, 1626.

British Museum, Egerton MS. 548.



JEAN BAPTISTE POQUELIN MOLIERE

It appears that in the year 1616 the church became at last aroused to the implications of the heliocentric doctrine of the universe. Apparently it seemed clear to the church authorities that the authors of the Bible believed the world to be immovably fixed at the center of the universe. Such, indeed, would seem to be the natural inference from various familiar phrases of the Hebrew text, and what we now know of the status of Oriental science in antiquity gives full warrant to this interpretation. There is no reason to suppose that the conception of the subordinate place of the world in the solar system had ever so much as occurred, even as a vague speculation, to the authors of Genesis. In common with their contemporaries, they believed the earth to be the all-important body in the universe, and the sun a luminary placed in the sky for the sole purpose of giving light to the earth.

There is nothing strange, nothing anomalous, in this view; it merely reflects the current notions of Oriental peoples in antiquity. What is strange and anomalous is the fact that the Oriental dreamings thus expressed could have been supposed to represent the acme of scientific knowledge.

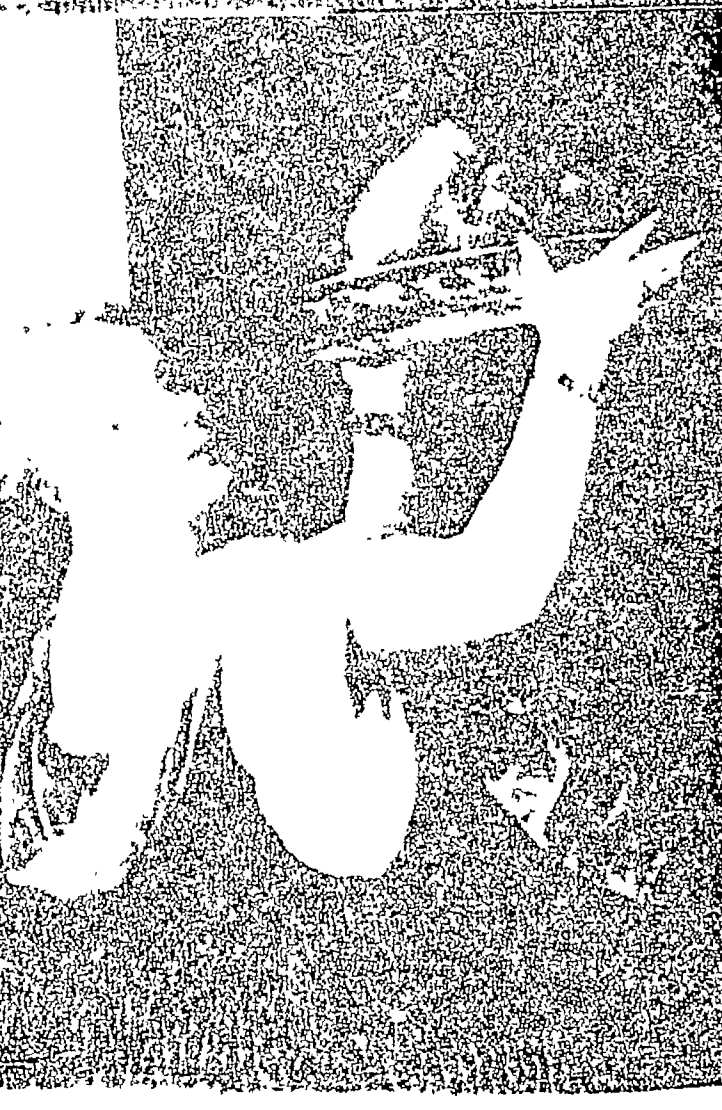
Yet such a hold had these writings taken upon the Western world that not even a Galileo dared contradict them openly; and when the church fathers gravely declared the heliocentric theory necessarily false, because contradictory to Scripture, there were probably few people in Christendom whose mental attitude would permit them justly to appreciate the humor of such a pronouncement. And, indeed, if here and there a man might have risen to such an appreciation, there were abundant reasons for the repression of the impulse, for there was nothing humorous about the response with

which the authorities of the time were wont to meet the expression of iconoclastic opinions. The burning at the stake of Giordano Bruno, in the year 1600, was, for example, an object-lesson well calculated to restrain the enthusiasm of other similarly minded teachers

Doubtless it was such considerations that explained the relative silence of the champions of the Copernican theory, accounting for the otherwise inexplicable fact that about eighty years elapsed after the death of Copernicus himself before a single text-book expounded his theory.

The text-book which then appeared, under date of 1622, was written by the famous Kepler, who perhaps was shielded in a measure from the papal consequences of such hardihood by the fact of residence in a Protestant country. Not that the Protestants of the time favored the heliocentric doctrine—we have already quoted Luther in an adverse sense—but of course it was characteristic of the Reformation temper to oppose any papal pronouncement, hence the ultramontane declaration of 1616 may indirectly have aided the doctrine which it attacked, by making that doctrine less obnoxious to Lutheran eyes. Be that as it may, the work of Kepler brought its author into no direct conflict with the authorities.

But the result was quite different when, in 1632, Galileo at last broke silence and gave the world, under cover of the form of dialog, an elaborate exposition of the Copernican theory Galileo, it must be explained, had previously been warned to keep silent on the subject, hence his publication doubly offended the authorities To be sure, he could reply that his dialog introduced a champion of the Ptolemaic system to dispute with the upholder of the opposite view, and that, both views be



ing presented with full array of argument, the reader was left to reach a verdict for himself, the author having nowhere pointedly expressed an opinion. But such an argument, of course, was specious, for no one who read the dialog could be in doubt as to the opinion of the author. Moreover, it was hinted that Simplicio, the character who upheld the Ptolemaic doctrine and was everywhere worsted in the argument, was intended to represent the pope himself—a suggestion which probably did no good to Galileo's cause.

The work was widely circulated, and it was received with an interest which suggests a widespread undercurrent of belief in the Copernican doctrine. Naturally enough, it attracted immediate attention from the church authorities. Galileo was summoned to appear at Rome to defend his conduct. The philosopher, who was now in his seventieth year, pleaded age and infirmity. He had no desire for personal experience of the tribunal of the Inquisition; but the mandate was repeated, and Galileo went to Rome There, as every one knows, he disavowed any intention to oppose the teachings of Scripture, and formally renounced the heretical doctrine of the earth's motion.

According to a tale which so long passed current that every historian must still repeat it tho no one now believes it authentic, Galileo qualified his renunciation by muttering to himself, "E pur si muove" (It does move, none the less), as he rose to his feet and retired from the presence of his persecutors The tale is one of those fictions which the dramatic sense of humanity is wont to impose upon history, but, like most such fictions, it expresses the spirit if not the letter of truth; for just as no one believes Galileo's lips uttered the phrase, so no one doubts that the rebellious words were in his mind.

After his formal renunciation, Galileo was allowed to depart, but with the injunction that he abstain in future from heretical teaching. The remaining ten years of his life were devoted chiefly to mechanics, where his experiments fortunately opposed the Aristotelian rather than the Hebrew teachings. Galileo's death occurred in 1642, a hundred years after the death of Copernicus Kepler had died thirteen years before, and there remained no astronomer in the field who is conspicuous in the history of science as a champion of the Copernican doctrine. But in truth it might be said that the theory no longer needed a champion.

The researches of Kepler and Galileo had produced a mass of evidence for the Copernican theory which amounted to demonstration A generation or two might be required for this evidence to make itself everywhere known among men of science, and of course the ecclesiastical authorities must be expected to stand by their guns for a somewhat longer period. In point of fact, the ecclesiastical ban was not technically removed by the striking of the Copernican books from the list of the Index Expurgatorius until the year 1822, almost two hundred years after the date of Galileo's dialog. But this, of course, is in no sense a guide to the state of general opinion regarding the theory. We shall gain a true gage as to this if we assume that the greater number of important thinkers had accepted the heliocentric doctrine before the middle of the seventeenth century, and that before the close of that century the old Ptolemaic idea had been quite abandoned. A wonderful revolution in man's estimate of the universe had thus been effected within about two centuries after the birth of Copernicus

II

THE AGE OF NEWTON

GALILEO, that giant in physical science of the early seventeenth century, died in 1642. On Christmas day of the same year there was born in England another intellectual giant who was destined to carry forward the work of Copernicus, Kepler, and Galileo to a marvelous consummation through the discovery of the great unifying law in accordance with which the planetary motions are performed. This was the greatest of English physical scientists, Isaac Newton, the Shakespeare of the scientific world.

Born thus before the middle of the seventeenth century, Newton lived beyond the first quarter of the eighteenth (1727). For the last forty years of that period his was the dominating scientific personality of the world. With full propriety that time has been spoken of as the "Age of Newton."

Yet the man who was to achieve such distinction gave no early premonition of future greatness. He was a sickly child from birth, and a boy of little seeming promise. He was an indifferent student, yet, on the other hand, he cared little for the common amusements of boyhood. He early exhibited, however, a taste for mechanical contrivances, and spent much time in devising windmills, water-clocks, sun-dials, and kites. While other boys were interested only in having kites that would fly, Newton—at least so the stories of a later time would have us understand—cared more for the investigation of the seeming

principles involved, or for testing the best methods of attaching the strings, or the best materials to be used in construction.

Meanwhile the future philosopher was acquiring a taste for reading and study, delving into old volumes whenever he found an opportunity. These habits convinced his relatives that it was useless to attempt to make a farmer of the youth, as had been their intention. He was therefore sent back to school, and in the summer of 1661 he matriculated at Trinity College, Cambridge

Even at college Newton seems to have shown no unusual mental capacity, and in 1664, when examined for a scholarship by Dr. Barrow, that gentleman is said to have formed a poor opinion of the applicant. It is said that the knowledge of the estimate placed upon his abilities by his instructor piqued Newton, and led him to take up in earnest the mathematical studies in which he afterwards attained such distinction. The study of Euclid and Descartes's *Geometry* roused in him a latent interest in mathematics, and from that time forward his investigations were carried on with enthusiasm In 1667 he was elected Fellow of Trinity College, taking the degree of M.A. the following spring.

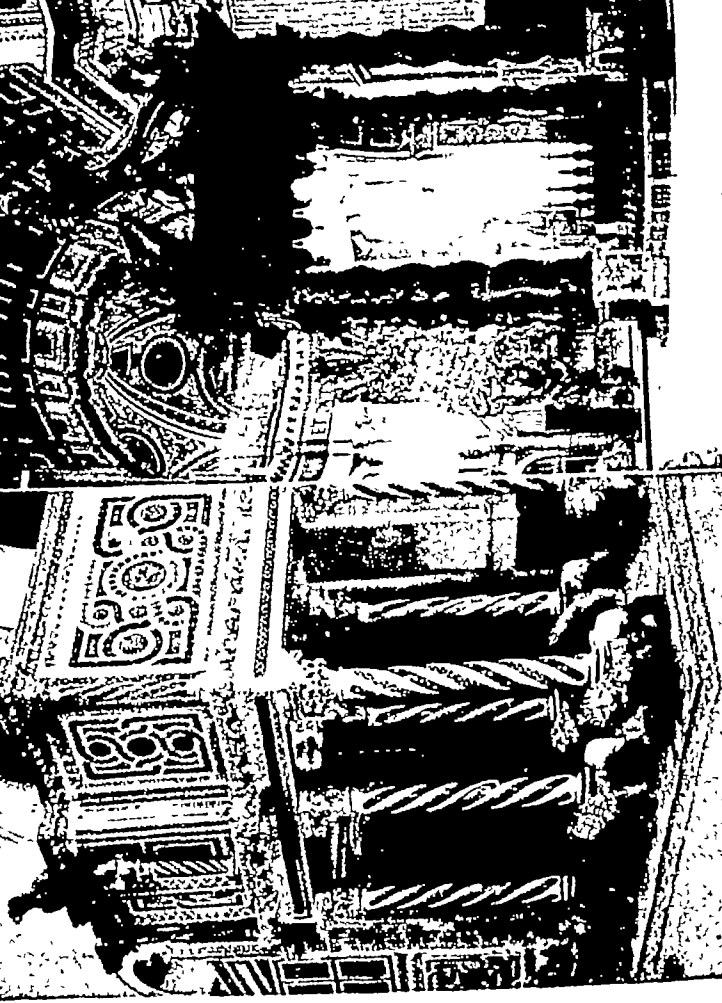
It will thus appear that Newton's boyhood and early manhood were passed during that troublous time in British political annals which saw the overthrow of Charles I., the autocracy of Cromwell, and the eventual restoration of the Stuarts. His maturer years witnessed the overthrow of the last Stuart and the reign of the Dutchman, William of Orange In his old age he saw the first of the Hanoverians mount the throne of England Within a decade of his death such scientific pathfinders as Cavendish, Black, and Priestley were born--men who lived on to the close of the eighteenth century.

In a full sense, then, the age of Newton bridges the gap from that early time of scientific awakening under Kepler and Galileo to the time which we of the twentieth century think of as essentially modern.

In December, 1672, Newton was elected a Fellow of the Royal Society, and at this meeting a paper describing his invention of the refracting telescope was read. A few days later he wrote to the secretary, making some inquiries as to the weekly meetings of the society, and intimating that he had an account of an interesting discovery that he wished to lay before the society. When this communication was made public, it proved to be an explanation of the discovery of the composition of white light.

The question as to the nature of color had commanded the attention of such investigators as Huygens, but no very satisfactory solution of the question had been attained Newton proved by demonstrative experiments that white light is composed of the blending of the rays of diverse colors, and that the color that we ascribe to any object is merely due to the fact that the object in question reflects rays of that color, absorbing the rest. That white light is really made up of many colors blended would seem incredible had not the experiments by which this composition is demonstrated become familiar to every one. The experiments were absolutely novel when Newton brought them forward, and his demonstration of the composition of light was one of the most striking expositions ever brought to the attention of the Royal Society It is hardly necessary to add that, notwithstanding the conclusive character of Newton's work, his explanations did not for a long time meet with general acceptance

Newton was led to his discovery by some experiments



ROMANESQUE COLUMNS AND INTERIOR
OF ST PETER'S

made with an ordinary glass prism applied to a hole in the shutter of a darkened room, the refracted rays of the sunlight being received upon the opposite wall and forming there the familiar spectrum.

This epoch-making paper aroused a storm of opposition. Some of Newton's opponents criticized his methods, others even doubted the truth of his experiments There was one slight mistake in Newton's belief that all prisms would give a spectrum of exactly the same length, and it was some time before he corrected this error Meanwhile he patiently met and answered the arguments of his opponents until he began to feel that patience was no longer a virtue. At one time he even went so far as to declare that, once he was "free of this business," he would renounce scientific research forever, at least in a public way. Fortunately for the world, however, he did not adhere to this determination, but went on to even greater discoveries—which, it may be added, involved still greater controversies.

In commenting on Newton's discovery of the composition of light, Voltaire said:

"Sir Isaac Newton has demonstrated to the eye, by the bare assistance of a prism, that light is a composition of colored rays, which, being united, form white color. A single ray is by him divided into seven, which all fall upon a piece of linen or a sheet of white paper, in their order one above the other, and at equal distances The first is red, the second orange, the third yellow, the fourth green, the fifth blue, the sixth indigo, the seventh a violet purple. Each of these rays transmitted afterwards by a hundred other prisms will never change the color it bears; in like manner as gold, when completely purged from its dross, will never change afterwards in the crucible."

We come now to the story of what is by common consent the greatest of scientific achievements. The law of universal gravitation is the most far-reaching principle as yet discovered. It has application equally to the minutest particle of matter and to the most distant suns in the universe, yet it is amazing in its very simplicity. As usually phrased, the law is this: That every particle of matter in the universe attracts every other particle with a force that varies directly with the mass of the particles and inversely as the squares of their mutual distance.

Newton did not vault at once to the full expression of this law, tho he had formulated it fully before he gave the results of his investigations to the world. We have now to follow the steps by which he reached this culminating achievement.

At the very beginning we must understand that the idea of universal gravitation was not absolutely original with Newton. Away back in the old Greek days, as we have seen, Anaxagoras conceived and clearly expressed the idea that the force which holds the heavenly bodies in their orbits may be the same that operates upon substances at the surface of the earth. With Anaxagoras this was scarcely more than a guess. After his day the idea seems not to have been expressed by any one until the seventeenth century's awakening of science. Then the consideration of Kepler's Third Law of planetary motion suggested to many minds perhaps independently the probability that the force hitherto mentioned merely as centripetal, through the operation of which the planets are held in their orbits, is a force varying inversely as the square of the distance from the sun.

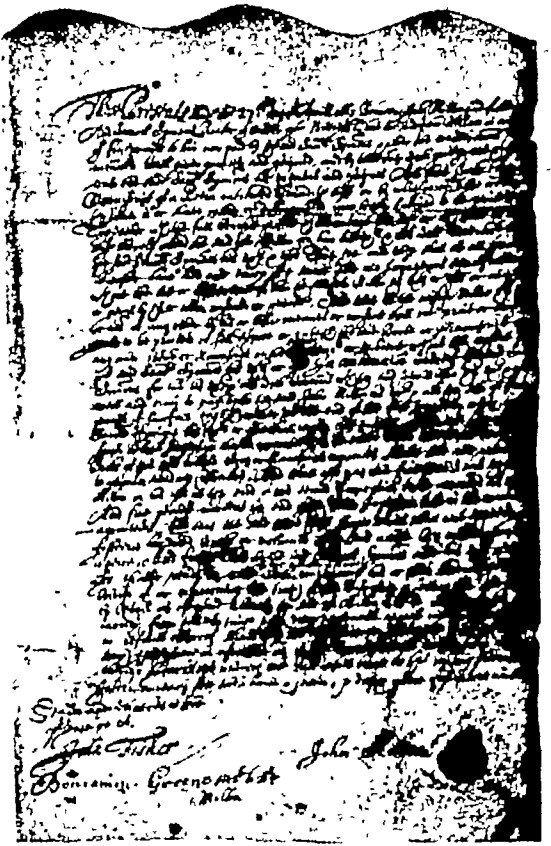
This idea had come to Robert Hooke, to Wren, and perhaps to Halley, as well as to Newton; but as yet no

one had conceived a method by which the validity of the suggestion might be tested. It was claimed later on by Hooke that he had discovered a method demonstrating the truth of the theory of inverse squares, and after the full announcement of Newton's discovery a heated controversy was precipitated in which Hooke put forward his claims with accustomed acrimony Hooke, however, never produced his demonstration, and it may well be doubted whether he had found a method which did more than vaguely suggest the law which the observations of Kepler had partially revealed.

Newton's great merit lay not so much in conceiving the law of inverse squares as in the demonstration of the law. He was led to this demonstration through considering the orbital motion of the moon.

According to the familiar story, which has become one of the classic myths of science, Newton was led to take up the problem through observing the fall of an apple Voltaire is responsible for the story, which serves as well as another, its truth or falsity need not in the least concern us Suffice it that through pondering on the familiar fact of terrestrial gravitation, Newton was led to question whether this force which operates so tangibly here at the earth's surface may not extend its influence out into the depths of space, so as to include, for example, the moon Obviously some force pulls the moon constantly toward the earth, otherwise that body would fly off at a tangent and never return May not this so-called centripetal force be identical with terrestrial gravitation? Such was Newton's query Probably many another man since Anaxagoras had asked the same question, but assuredly Newton was the first man to find an answer

The thought that suggested itself to Newton's mind



JOHN MILTON.

was this: If we make a diagram illustrating the orbital course of the moon for any given period, say one minute, we shall find that the course of the moon departs from a straight line during that period by a measurable distance—that is to say, the moon has been virtually pulled toward the earth by an amount that is represented by the difference between its actual position at the end of the minute under observation and the position it would occupy had its course been tangential, as, according to the first law of motion, it must have been had not some force deflected it toward the earth. Measuring the deflection in question—which is equivalent to the so-called versed sine of the arc traversed—we have a basis for determining the strength of the deflecting force.

Newton constructed such a diagram, and, measuring the amount of the moon's departure from a tangential rectilinear course in one minute, determined this to be, by his calculation, thirteen feet. Obviously, then, the force acting upon the moon is one that would cause that body to fall toward the earth to the distance of thirteen feet in the first minute of its fall. Would such be the force of gravitation acting at the distance of the moon if the power of gravitation varies inversely as the square of the distance? That was the tangible form in which the problem presented itself to Newton.

The mathematical solution of the problem was simple enough. It is based on a comparison of the moon's distance with the length of the earth's radius. On making this calculation, Newton found that the pull of gravitation—if that were really the force that controls the moon—gives that body a fall of slightly over fifteen feet in the first minute, instead of thirteen feet. Here was surely a suggestive approximation, yet, on the other

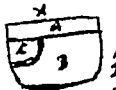
hand, the discrepancy seemed to be too great to warrant him in the supposition that he had found the true solution. He therefore dismissed the matter from his mind for the time being, nor did he return to it definitely for some years.

It was to appear in due time that Newton's hypothesis was perfectly valid and that his method of attempted demonstration was equally so The difficulty was that the earth's proper dimensions were not at that time known A wrong estimate of the earth's size vitiated all the other calculations involved, since the measurement of the moon's distance depends upon the observation of the parallax, which cannot lead to a correct computation unless the length of the earth's radius is accurately known.

Newton's first calculation was made as early as 1666, and it was not until 1682 that his attention was called to a new and apparently accurate measurement of a degree of the earth's meridian made by the French astronomer Picard The new measurement made a degree of the earth's surface 69.10 miles, instead of sixty miles

Learning of this materially altered calculation as to the earth's size, Newton was led to take up again his problem of the falling moon. As he proceeded with his computation, it became more and more certain that this time the result was to harmonize with the observed facts. As the story goes, he was so completely overwhelmed with emotion that he was forced to ask a friend to complete the simple calculation. That story may well be true, for, simple tho the computation was, its result was perhaps the most wonderful demonstration hitherto achieved in the entire field of science.

Now at last it was known that the force of gravitation operates at the distance of the moon, and holds that



JOHN LOCKE.

Date, 1679.

British Museum, Add. MS. 15,642.

Sr.

I have perused yor very ingenious Theory of Vision in wch (to be free wth you as a friend should be) there seems to be some things more solid & satisfactory, others more disputable but yet plausibly suggested & well deserving ye consideration of ye ingenious. The more satisfactory I take to be your asserting yt we see wth both eyes at once, yor speculation about ye use of ye musculus obliquus inferior, yor assigning every fibre in ye optick nerve of one eye to have its correspondent in yt of ye other, both wch make all things appear to both eyes in one & ye same place & yor solving hereby ye duplicity of ye object in distorted eyes & confuting ye childish opinion about ye splitting of ye optick nerves. The more disputable seems yor notion about every pair of fellow fibres being unisons to one another, discords to ye rest, & this consonance making ye object seen wth two eyes appear but one for ye same reason that unison sounds seem but one sound. I did think to have sent you what I fancy may be objected against this wch I had not time to write it down, but upon second thoughts I had rather reserve it for discourse at or next meeting, & therefore shall add only my thanks for yor kind letter & present

Sr I am

Yor much obliged & humble Servant

Is. Newton.

From Coll. Cambridge
June 20th 1682

SIR ISAAC NEWTON

Date, 1682

British Museum, Additional MS 4237

body in its elliptical orbit, and it required but a slight effort of the imagination to assume that the force which operates through such a reach of space extends its influence yet more widely. That such is really the case was demonstrated presently through calculations as to the moons of Jupiter and by similar computations regarding the orbital motions of the various planets.

All results harmonizing, Newton was justified in reaching the conclusion that gravitation is a universal property of matter It remained for nineteenth-century scientists to prove that the same force actually operates upon the stars, tho it should be added that this demonstration merely fortified a belief that had already found full acceptance

The very magnitude of the importance of the theory of universal gravitation made its general acceptance a matter of considerable time after the actual discovery. This opposition had of course been foreseen by Newton, and, much as he dreaded controversy, he was prepared to face it and combat it to the bitter end. He knew that his theory was right; it remained for him to convince the world of its truth. He knew that some of his contemporaries would accept it at once; others would at first doubt, question, and dispute, but finally accept; while still others would doubt and dispute until the end of their days. This had been the history of other great discoveries; and this will probably be the history of most great discoveries for all time. But in this case the discoverer lived to see his theory accepted by practically all the great minds of his time.

Delambre is authority for the following estimate of Newton by Lagrange. "The celebrated Lagrange," he says, "who frequently asserted that Newton was the greatest genius that ever existed, used to add—'and the

most fortunate, for we cannot find more than once a system of the world to establish ' " With pardonable exaggeration the admiring followers of the great generalizer pronounced this epitaph:

Nature and Nature's laws lay hid in night,
God said "Let Newton be!" and all was light

THE INFANT ST JOHN, BY MURILLO

REMBRANDT: THE BURGOMASTERS

THE ANATOMY LESSON

III

FROM PARACELSUS TO HARVEY

IN the year 1526 there appeared a new lecturer on the platform at the University at Basel—a small, beardless, effeminate-looking person — who had already inflamed all Christendom with his peculiar philosophy, his revolutionary methods of treating diseases, and his unparalleled success in curing them. A man who was to be remembered in after-time by some as the father of modern chemistry and the founder of modern medicine; by others as madman, charlatan, impostor; and by still others as a combination of all these. This soft-cheeked, effeminate, woman-hating man, whose very sex has been questioned, was Theophrastus von Hohenheim, better known as Paracelsus (1493-1541).

To appreciate his work, something must be known of the life of the man. He was born near Maria-Einsiedeln, in Switzerland, the son of a poor physician of the place. He began the study of medicine under the instruction of his father, and later on came under the instruction of several learned churchmen At the age of sixteen he entered the University of Basel, but, soon becoming disgusted with the philosophical teachings of the time, he quitted the scholarly world of dogmas and theories and went to live among the miners in the Tyrol, in order that he might study nature and men at first hand.

Ordinary methods of study were thrown aside, and he devoted his time to personal observation—the only true means of gaining useful knowledge, as he preached

and practised ever after. Here he became familiar with the art of mining, learned the physical properties of minerals, ores, and metals, and acquired some knowledge of mineral waters More important still, he came in contact with such diseases, wounds, and injuries as miners are subject to, and he tried his hand at the practical treatment of these conditions, untrammeled by the traditions of a profession in which his training had been so scant.

Having acquired some empirical skill in treating diseases, Paracelsus set out wandering from place to place all over Europe, gathering practical information as he went, and learning more and more of the medicinal virtues of plants and minerals His wanderings covered a period of about ten years, at the end of which time he returned to Basel, where he was soon invited to give a course of lectures in the university.

These lectures were revolutionary in two respects—they were given in German instead of time-honored Latin, and they were based upon personal experience rather than upon the works of such writers as Galen and Avicenna Indeed, the iconoclastic teacher spoke with open disparagement of these revered masters, and openly upbraided his fellow-practitioners for following their tenets.

Naturally such teaching raised a storm of opposition among the older physicians, but for a time the unparalleled success of Paracelsus in curing diseases more than offset his unpopularity. Gradually, however, his bitter tongue and his coarse personality rendered him so unpopular, even among his patients, that, finally, his liberty and life being jeopardized, he was obliged to flee from Basel, and became a wanderer. He lived for brief periods in Colmar, Nuremberg, Appenzell, Zurich, Pfeffers, Augsburg, and several other cities, until finally at Salzburg

his eventful life came to a close in 1541. His enemies said that he had died in a tavern from the effects of a protracted debauch; his supporters maintained that he had been murdered at the instigation of rival physicians and apothecaries.

But the effects of his teachings had taken firm root, and continued to spread after his death He had shown the fallibility of many of the teachings of the hitherto standard methods of treating diseases, and had demonstrated the advantages of independent reasoning based on observation.

His influence upon medicine rests undoubtedly upon his revolutionary attitude, rather than on any great or new discoveries made by him. It is claimed by many that he brought prominently into use opium and mercury, and if this were indisputably proven his services to medicine could hardly be overestimated Unfortunately, however, there are good grounds for doubting that he was particularly influential in reintroducing these medicines His chief influence may perhaps be summed up in a single phrase—he overthrew old traditions.

To Paracelsus's endeavors, however, if not to the actual products of his work, is due the credit of setting in motion the chain of thought that developed finally into scientific chemistry. Nor can the ultimate aim of the modern chemist seek a higher object than that of this sixteenth-century alchemist, who taught that "true alchemy has but one aim and object, to extract the quintessence of things, and to prepare arcana, tinctures, and elixirs which may restore to man the health and soundness he has lost."

About the beginning of the sixteenth century, while Paracelsus was scoffing at the study of anatomy as useless, and using his influence against it, there had already

MOZART

come upon the scene the first of the great anatomists whose work was to make the century conspicuous in that branch of medicine

The young anatomist Charles Etienne (1503-1564) made one of the first noteworthy discoveries, pointing out for the first time that the spinal cord contains a canal, continuous throughout its length. He also made other minor discoveries of some importance, but his researches were completely overshadowed and obscured by the work of a young Fleming who came upon the scene a few years later, and who shone with such brilliancy in the medical world that he obscured completely the work of his contemporary until many years later.

This young physician, who was destined to lead such an eventful career and meet an untimely end as a martyr to science, was Andrew Vesalius (1514-1564), who is called the "greatest of anatomists." At the time he came into the field medicine was struggling against the dominating Galenic teachings and the theories of Paracelsus, but perhaps most of all against the superstitions of the time. In France human dissections were attended with such dangers that the young Vesalius transferred his field of labors to Italy, where such investigations were covertly permitted, if not openly countenanced

From the very start the young Fleming looked askance at the accepted teachings of the day, and began a series of independent investigations based upon his own observations. The results of these investigations he gave in a treatise on the subject which is regarded as the first comprehensive and systematic work on human anatomy. This remarkable work was published in the author's twenty-eighth or twenty-ninth year Soon after this Vesalius was invited as imperial physician to the court of Emperor Charles V. He continued to act in the same

capacity at the court of Philip II after the abdication of his patron. But in spite of this royal favor there was at work a factor more powerful than the influence of the monarch himself—an instrument that did so much to retard scientific progress, and by which so many lives were brought to a premature close

Vesalius had received permission from the kinsmen of a certain grandee to perform an autopsy While making his observations the heart of the outraged body was seen to palpitate—so at least it was reported. This was brought immediately to the attention of the Inquisition, and it was only by the intervention of the king himself that the anatomist escaped the usual fate of those accused by that tribunal As it was, he was obliged to perform a pilgrimage to the Holy Land. While returning from this he was shipwrecked, and perished from hunger and exposure on the island of Zante

At the very time when the anatomical writings of Vesalius were startling the medical world, there was living and working contemporaneously another great anatomist, Eustachius (died 1574), whose records of his anatomical investigations were ready for publication only nine years after the publication of the work of Vesalius. Owing to the unfortunate circumstances of the anatomist, however, they were never published during his lifetime—not, in fact, until 1714. When at last they were given to the world as *Anatomical Engravings*, they showed conclusively that Eustachius was equal, if not superior to Vesalius in his knowledge of anatomy It has been said of this remarkable collection of engravings that if they had been published when they were made in the sixteenth century, anatomy would have been advanced by at least two centuries They certainly show that their author was a most careful dissector and observer

Eustachius described accurately for the first time certain structures of the middle ear, and rediscovered the tube leading from the ear to the throat that bears his name He also made careful studies of the teeth and the phenomena of first and second dentition. He was not baffled by the minuteness of structures and where he was unable to study them with the naked eye he used glasses for the purpose, and resorted to macerations and injections for the study of certain complicated structures But while the fruit of his pen and pencil were lost for more than a century after his death, the effects of his teachings were not, and his two pupils, Fallopius and Columbus, are almost as well known today as their illustrious teacher. Columbus (1490-1559) did much in correcting the mistakes made in the anatomy of the bones as described by Vesalius He also added much to the science by giving correct accounts of the shape and cavities of the heart, and made many other discoveries of minor importance Fallopius (1523-1562) added considerably to the general knowledge of anatomy, made several discoveries in the anatomy of the ear, and also of certain organs in the abdominal cavity.

At this time a most vitally important controversy was in progress as to whether or not the veins of the bodies were supplied with valves, many anatomists being unable to find them. Etienne had first described these structures, and Vesalius had confirmed his observations. It would seem as if there could be no difficulty in settling the question as to the fact of such valves being present in the vessels, for the demonstration is so simple that it is now made daily by medical students in all physiological laboratories and dissecting-rooms. But many of the great anatomists of the sixteenth century were unable to make this demonstration, even when it had been

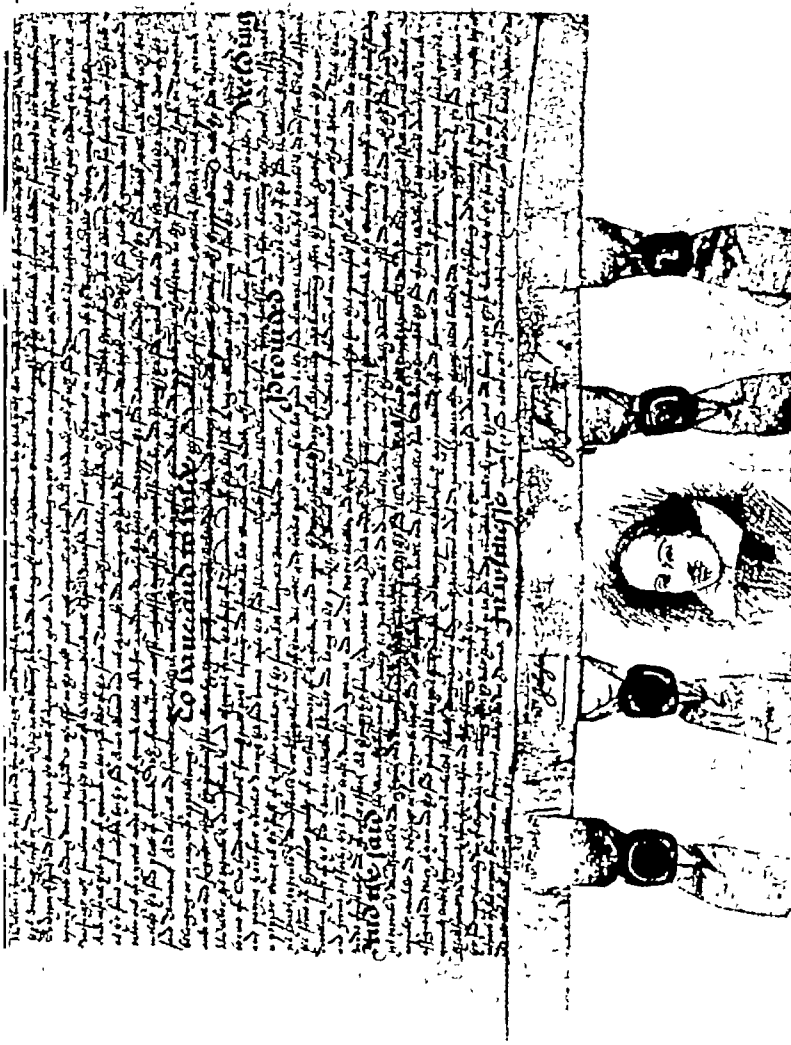
brought to their attention by such an authority as Vesalius. Fallopius, writing to Vesalius on the subject in 1562, declared that he was unable to find such valves Others, however, including Eustachius and Fabricius (1537-1619), were more successful, and found and described these structures

But the purpose served by these valves was entirely misinterpreted It was supposed that they act in retarding the flow of the blood as it comes *from* the heart, and thus prevent its too rapid distribution throughout the body. That the blood might be going toward the heart, instead of coming from it, seems never to have been considered seriously until demonstrated so conclusively by Harvey.

Among the anatomists who probably discovered these valves was Michael Servetus (1511-1553); but if this is somewhat in doubt, it is certain that he discovered and described the pulmonary circulation, and had a very clear idea of the process of respiration as carried on in the lungs The description was contained in a famous document sent to Calvin in 1545—a document which the reformer carefully kept for seven years in order that he might make use of some of the heretical statements it contained The awful fate of Servetus, the interesting character of the man, and the fact that he came so near to anticipating the discoveries of Harvey make him one of the most interesting figures in medical history

The time was ripe for the culminating discovery of the circulation of the blood; but as yet no one had determined the all-important fact that there are two currents of blood in the body, one going to the heart, one coming from it.

The valves in the veins would seem to show conclusively that the venous current did not come from the



SHAKESPEARE A LEGAL DOCUMENT BEARING HIS SIGNATURE

THE EPISTLE.

THE MASQVE OF QVEENES.

heart, and surgeons must have observed thousands of times the every-day phenomenon of congested veins at the distal extremity of a limb around which a ligature or constriction of any kind had been placed, and the simultaneous depletion of the vessels at the proximal points above the ligature.

But it should be remembered that inductive science was in its infancy. This was the sixteenth, not the nineteenth century, and few men had learned to put implicit confidence in their observations and convictions when opposed to existing doctrines

The time was at hand, however, when such a man was to make his appearance, and, as in the case of so many revolutionary doctrines in science, this man was an Englishman It remained for William Harvey (1578-1657) to solve the great mystery which had puzzled the medical world since the beginning of history; not only to solve it, but to prove his case so conclusively and so simply that for all time his little book must be handed down as one of the great masterpieces of lucid and almost faultless demonstration

Harvey, the son of a prosperous Kentish yeoman, was born at Folkestone. His education was begun at the grammar school of Canterbury, and later he became a pensioner of Caius College, Cambridge.

Soon after taking his degree of B.A., at the age of nineteen, he decided upon the profession of medicine, and went to Padua as a pupil of Fabricius and Casserius.

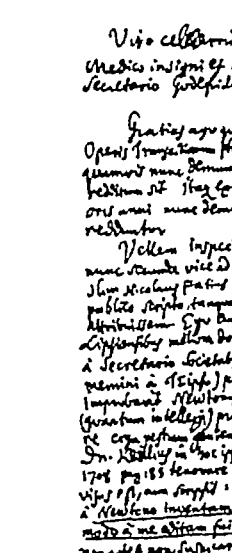
Returning to England at the age of twenty-four, he soon after (1609) obtained the reversion of the post of physician to St Bartholomew's Hospital, his application being supported by James I himself. Even at this time he was a popular physician, counting among his patients such men as Francis Bacon

In 1618 he was appointed physician extraordinary to the king, and, a little later, physician in ordinary. He was in attendance upon Charles I at the battle of Edgehill, in 1642, where, with the young Prince of Wales and the Duke of York, after seeking shelter under a hedge, he drew a book out of his pocket and, forgetful of the battle, became absorbed in study, until finally the cannon-balls from the enemy's artillery made him seek a more sheltered position

On the fall of Charles I he retired from practise and lived in retirement with his brother He was then well along in years, but still pursued his scientific researches with the same vigor as before, directing his attention chiefly to the study of embryology. On June 3, 1657, he was attacked by paralysis and died, in his eightieth year He had lived to see his theory of the circulation accepted, several years before, by all the eminent anatomists of the civilized world

A keenness in the observation of facts, characteristic of the mind of the man, had led Harvey to doubt the truth of existing doctrines as to the phenomena of the circulation.

Galen had taught that "the arteries are filled, like bellows, because they are expanded," but Harvey thought that the action of spurting blood from a severed vessel disproved this For the spurting was remittent, "now with greater, now with less impetus," and its greater force always corresponded to the expansion (diastole), not the contraction (systole) of the vessel Furthermore, it was evident that contraction of the heart and the arteries was not simultaneous, as was commonly taught, because in that case there would be no marked propulsion of the blood in any direction, and there was no gainsaying the fact that the blood was forcibly pro-



GOTTFRIED WILHELM LEIBNITZ

Date 1711

British Museum, Sloane MS 4042

endeavours to translate him and he is so far complyd with the Taste of the Age that his whole Book is over-run with Texts of Scripture and the Notion of Providence supposd to be stole from two Verses out of the Prophets. Nay the Humour is grown so Universal that tis got among the Poets, who are every day publishing Legends and Lives of Saints & Martyrs. My Imperfect Acquaintance with the French Language made me incapable of learning any more particular News of this kind, so that I must end my letter as I began it with my most Humble Acknowledgements for all Your favours

I am, Honoured Sir,

Blois. 8br. 14.
1699

Yr
most Obliged and most
obedient Humble Servant

J. Addison

JOSEPH ADDISON.

Date, 1699.

British Museum, Add. MS. 7,121

pelled in a definite direction, and that direction away from the heart.

Harvey's investigations led him to doubt also the accepted theory that there was a porosity in the septum of tissue that divides the two ventricles of the heart. It seemed unreasonable to suppose that a thick fluid like the blood could find its way through pores so small that they could not be demonstrated by any means devised by man. In evidence that there could be no such openings he pointed out that, since the two ventricles contract at the same time, this process would impede rather than facilitate such an intra-ventricular passage of blood.

But what seemed the most conclusive proof of all was the fact that in the fetus there existed a demonstrable opening between the two ventricles, and yet this is closed in the fully developed heart

Why should Nature, if she intended that blood should pass between the two cavities, choose to close this opening and substitute microscopic openings in place of it? It would surely seem more reasonable to have the small perforations in the thin, easily permeable membrane of the fetus, and the opening in the adult heart, rather than the reverse.

From all this Harvey drew his correct conclusions, declaring earnestly, "By Hercules, there *are* no such porosities, and they cannot be demonstrated."

Having convinced himself that no intra-ventricular opening existed, he proceeded to study the action of the heart itself, untrammeled by too much faith in established theories, and, as yet, with no theory of his own. He soon discovered that the commonly accepted theory of the heart striking against the chest-wall during the period of relaxation was entirely wrong, and that its action was exactly the reverse of this, the heart striking

(which may be very probable considering the many Drugs I take) if I remember to have mentioned that word in my Letter. But, Ladyes who have Poison in their eyes, may be apt to mistake in reading — Oh, I have found it out; the word Porter I suppose was written like Poison: ask all the Friends I write to, and they will attest this mistake to be but a trifle in my way of writing, and could easily prove it if I had any of my Letter to them: I make no nothing of mistaking untoward for Howard, Wolf quilt for Walpole, Slily for Sly Knights of a Shire for Knights of a Shire, Minister for Minister, in writing Speaker I put an n for a p. and a hundred such Blunders, which cannot be helped while I have a hundred ossany roaring in my ears into which no soup hath been poured this fortnight, and therefore if I write nonsense, I can assure you it is genuine and not borrowed.

Thus I write to you my commands and besides I am bound in duty to be the last writer. But deaf or giddy, hearing or steady, I shall be ever with the truest respect

Twitenham
Aug. 19th 1727

Sir Your most obliged and
most humble Servant
Jonath: Swift.

22,625 f.18.

JONATHAN SWIFT

Date, 1727

British Museum, Add. MS. 22,625.

My Lord, Decemb^r. 3. 1714.

While you are doing Justice to all the World, I beg you will not forget Homer, if you can spare an hour to attend his cause. I leave him with you in that hope, and return home full of acknowledgments for the Favour your Lordship has done me, and for those you are pleas'd to intend me. I distrust neither your Will, nor your Memory, when it is to do Good: and if Sollicitous I become, Importunate or Solliciteous, it must not be out of Expectation, but out of Gratitude. Your Lordship may either cause me to live agreeably in the Towne, or comfortably in the Country, which is really all the Difference I see between an Easy Fortune and a small one. It is indeed a high Strain of Generosity in you, to think of making me easie all my Life, only because I have been so happy as to divert you an hour or two. But if I may have leave to add, because you think me no Enemy to my Country, there will appear a better Reason, for I must be of consequence, as I sincerely am,

My Lord Y^r. most obliged, most obedient, & faithfull humble Servant
A Pope.

ALEXANDER POPE
(MS. OF 1714)

SAMUEL JOHNSON.

Date, 1749.

British Museum, King's MS. 306

[illegible]

Your obliged humble Servant
S. Richardson

Salisbury Court, Fleetstreet,
March 22. 1754.

SAMUEL RICHARDSON
Date 1754
[illegible]

the chest-wall during contraction. Having thus disproved the accepted theory concerning the heart's action, he took up the subject of the action of arteries, and soon was able to demonstrate by vivisection that the contraction of the arteries was not simultaneous with contractions of the heart. His experiments demonstrated that these vessels were simply elastic tubes whose pulsations were "nothing else than the impulse of the blood within them." The reason that the arterial pulsation was not simultaneous with the heart-beat he found to be because of the time required to carry the impulse along the tube.

By a series of further careful examinations and experiments, which are too extended to be given here, he was soon able further to demonstrate the action and course of the blood during the contractions of the heart His explanations were practically the same as those given today—first the contraction of the auricle, sending blood into the ventricle; then ventricular contraction, making the pulse, and sending the blood into the arteries

He had thus demonstrated what had not been generally accepted before, that the heart is an organ for the propulsion of blood It had been supposed to be an organ that was "in some mysterious way the source of vitality and warmth, as an animated crucible for the concoction of blood and the generation of vital spirits "

In watching the rapid and ceaseless contractions of the heart, Harvey was impressed with the fact that, even if a very small amount of blood was sent out at each pulsation, an enormous quantity must pass through the organ in a day, or even in an hour.

Estimating the size of the cavities of the heart, and noting that at least a dram must be sent out with each pulsation, it was evident that the two thousand beats given by a very slow human heart in an hour must send

out some forty pounds of blood—more than twice the amount in the entire body.

The question was, what became of it all? For it should be remembered that the return of the blood by the veins was unknown, and nothing like a "circulation" more than vaguely conceived even by Harvey himself.

Once it could be shown that the veins were constantly returning blood to the heart, the discovery that the blood in some way passes from the arteries to the veins was only a short step Harvey, by resorting to vivisections of lower animals and reptiles, soon demonstrated beyond question the fact that the veins do carry the return blood.

His next step was the natural one of demonstrating that the blood passes from the arteries to the veins. He demonstrated conclusively that this did occur, but for once his rejection of the ancient writers and one modern one was a mistake. For Galen had taught, and had attempted to demonstrate, that there are sets of minute vessels connecting the arteries and the veins; and Servetus had shown that there must be such vessels, at least in the lungs.

However, the little flaw in the otherwise complete demonstration of Harvey detracts nothing from the main issue at stake. It was for others who followed to show just how these small vessels acted in effecting the transfer of the blood from artery to vein, and the general statement that such a transfer does take place was, after all, the all-important one.

The last step of Harvey's demonstration was to prove that the blood does flow along the veins to the heart, aided by the valves that had been the cause of so much discussion and dispute between the great sixteenth-century anatomists. Harvey not only demonstrated the presence of these valves, but showed conclusively, by simple

FRANÇOIS MARIE AROUET DE VOLTAIRE.

Paris, 1760

British Museum, Add. MS. 30,910

It is agreed between Oliver Goldsmith M. B. on one hand
and James Dodsley on the other that Oliver Goldsmith shall
write for James Dodsley a book called a Chronological
history of the lives of eminent persons of Great Britain and
Ireland or to that effect, consisting of about two volumes
8vo about the same size and letter with the universal
history published in 8vo for the writing of which and com-
piling the same James Dodsley shall pay Oliver Goldsmith
three guineas for every printed sheet, so that the whole shall
be delivered complete in the space of two years at farthest James
Dodsley however shall print the above book in whatever manner
or size he shall think fit only the Universal history above
mentioned shall be the standard by which Oliver Goldsmith
shall expect to be paid. Oliver Goldsmith shall be paid one
moiety upon delivery of the whole copy complete, and the
other moiety one half of it at the conclusion of six months
and the other half at the expiration of twelve months next
after the publication of the work, [illegible] James Dodsley giving
however upon the delivery of the whole copy two notes for the
money left unpaid. Each volume of the above intended work
shall not contain more than five and thirty sheets and if they
should contain more the surplus shall not be paid for by
James Dodsley. [illegible] Oliver Goldsmith shall
prefix his name to the said work.

Mar 31. 1763

Oliver Goldsmith
Jas Dodsley

OLIVER GOLDSMITH.
[illegible]
[illegible]

You know our country custom of coupling a man and woman together as Partners in the labors of Harvest. In my fifteenth autumn, my Partner was a bewitching creature who just counted an autumn less. My scarcity of English denies me the power of doing her justice in that language; but you know the Scotch idiom, she was a bonie, sweet, sonsie lass. — In short, she altogether unwittingly to herself, initiated me in a certain delicious Passion, which in spite of acid Disappointment, gin-horse Prudence and bookworm Philosophy, I hold to be the first of human joys, our dearest pleasure here below. — How she caught the contagion I can't say; you medical folks talk much of infection by breathing the same air, the touch, &c. but I never expressly told her that I loved her. — Indeed I did not well know myself, why I liked so much to loiter behind with her, when returning in the evening from our labors, why the tones of her voice made my heartstrings thrill like an Eolian harp; and particularly, why my pulse beat such a furious ratann when I looked and fingered over her hand, to pick out the nettle-stings and thistles. — Among her other love-inspiring qualifications, she sung sweetly; and 'twas her favorite reel to which I attempted giving an embodied vehicle in rhyme. — I was not so presumptive as to imagine that I could make verses like printed ones composed by men who had Greek and Latin, but my girl sung a song which was said to be composed by a small country laird's son, on one of his father's maids, with whom he was in love; and I saw no reason why I might not rhyme as well as he, for excepting smearing sheep and casting peats, his father living in the moors, he had no more scholarcraft than I had. ——

Thus

ROBERT BURNS.

Date 1787

British Museum, Egerton MS 1660

IMMANUEL KANT

(1724–1804)

British Museum, Add. MS. 28,167

experiments, what their function was, thus completing his demonstration of the phenomena of the circulation

The final ocular demonstration of the passage of the blood from the arteries to the veins was not to be made until four years after Harvey's death This process, which can be observed easily in the web of a frog's foot by the aid of a low-power lens, was first demonstrated by Marcello Malpighi (1628-1694) in 1661 By the aid of a lens he first saw the small "capillary" vessels connecting the veins and arteries in a piece of dried lung Taking his cue from this, he examined the lung of a turtle, and was able to see in it the passage of the corpuscles through these minute vessels, making their way along these previously unknown channels from the arteries into the veins on their journey back to the heart Thus the work of Harvey, all but complete, was made absolutely entire by the great Italian And all this in a single generation.

The seventeenth century was not to close, however, without another discovery in science, which, when applied to the causation of disease almost two centuries later, revolutionized therapeutics more completely than any one discovery This was the discovery of microbes, by Antonius von Leeuwenhoek (1632-1723), in 1683 Von Leeuwenhoek discovered that "in the white matter between his teeth" there were millions of microscopic "animals"—more, in fact, than "there were human beings in the United Netherlands," and all "moving in the most delightful manner " There can be no question that he saw them, for we can recognize in his descriptions of these various forms of little "animals" the four principal forms of microbes—the long and short rods of bacilli and bacteria, the spheres of micrococci, and the corkscrew spirillum

The presence of these microbes in his mouth greatly annoyed Antonius, and he tried various methods of getting rid of them, such as using vinegar and hot coffee. In doing this he little suspected that he was anticipating modern antiseptic surgery by a century and three-quarters—attempting what antiseptic surgery is now able to accomplish. For the fundamental principle of antisepsis is the use of medicines for ridding wounds of similar microscopic organisms.

Von Leeuwenhoek was only temporarily successful in his attempts, however, and took occasion to communicate his discovery to the Royal Society of England, hoping that they would be "interested in this novelty." Probably they were, but not sufficiently so for any member to pursue any protracted investigations or reach any satisfactory conclusions, and the whole matter was practically forgotten until the middle of the nineteenth century.

DEATH OF CHOPIN